# JOURNAL

OF THE

# FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXLVI, No. 1. 73D YEAR. JULY, 1898



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## Mining and Metallurgical Section.

*Stated Meeting, November 10, 1897.*

### FORESTRY IN RELATION TO PHYSICAL GEOGRAPHY AND ENGINEERING.


BY JOHN GIFFORD,
Member of the Institute.


It is mainly the object of this paper to indicate that, wholly aside from the question of profit in the production of wood crops, the degree of benefit derived from the forest is sufficient to warrant any State in protecting woodland owned by private parties from reckless waste by fire. The State owes to every citizen and his property a reasonable amount of protection against incendiaries and those guilty of criminal carelessness with fire. A country in which the owners of property are at the mercy of greedy and insatiable corporations, malicious incendiaries and wood thieves is still, more or less, in a state of anarchy. The truth is easily

demonstrated that the root of the evil is in civic indifference, a lack of morality and patriotism, and selfish greed which is invariably engendered and actually fostered in forms of government where individual liberty has few limitations, and in many instances in certain localities runs rampant. It is not my intention to dwell upon this hopeless phase of the subject, but to refer briefly to a few of those indirect benefits of the forest, the importance of which cannot be measured in dollars and cents.

The Mangrove on the coast of Florida.

Dr. Karl Eckstein has just written a book on "Forstliche Zoologie," Dr. Frank Schwarz one on "Forstliche Botanik," and no doubt, among the countless German works on forestry, there is one or several on "Forst-Geologie."

The agencies which are active in modifying the structure of the surface of the earth are usually classed as atmospheric, aqueous, igneous and organic. Little is usually said in works on physical geography of vegetal agencies. Geographers generally have neglected to show the action of the

forest in this respect, to note the great changes occasioned in the nature of the earth's surface by forest destruction, and the methods employed in lessening or checking the destructive agencies of nature by means of the forest. It comes within the scope of physical geography to treat of these manifold agencies. Man, a potent agent in changing the nature of the earth's surface, may, by his carelessness let loose the destructive forces of nature by destroying the forest. Fertile regions have been turned into deserts, and floods, avalanches, earthslides, shifting sands, fevers and strong winds have been engendered or accelerated by forest destruction. On the other hand, by the application of forest planting and engineering skill, avalanches, earthslides and floods have been prevented, shifting sands fixed, sterile lands rendered productive, and malarial lowlands healthy. The forest is the instrument by means of which he can harness and control these unruly forces.

Although of great importance in this connection, I shall little more than mention the work of the mangrove tree, the great land-former, which, supplementing the work of the coral-polyp, has added to the warm seashore regions of the globe immense areas of land. These trees grow in salt water several feet in depth; their labyrinth of roots and branches collect and hold sediment and flotage. Thus the shore-line advances. The seeds of the mangrove germinate while still attached to the parent plant. These plantlets fall into the water, float away until their roots touch the bottom, to which they at once fix themselves. Detritus accumulates, birds, wind and water bring seeds and soon the island is richly covered with vegetation and fit for human habitation.

I shall only mention, also, in passing, that vast areas, formerly malarial and swampy, have been rendered healthy by planting the eucalyptus, and that vast fertile regions of the tropical world have been explored and exploited through the aid of quinine, a product of the cinchona tree.

Unlike other crops, the forest constantly improves the soil, provided the litter is not removed or allowed to burn. The roots of trees penetrate to its deeper layers, and absorb

large quantities of mineral matters. A large percentage of this material goes to the leaves, and is deposited on the surface. The surface soil is both enriched by these mineral substances and protected by a mulch of humus in varying stages of decomposition. As the lower layers rot, new layers of leaves and twigs are being constantly deposited, so that the forest soil, in the course of time, fairly reeks with nourishing plant-food, which seeps out more or less to enrich neighboring soils. The German peasants know well the great manurial value of the forest litter. They have, only after years of coaxing and forcing in certain localities, relinquished their rights to litter and pannage in communal forests. These rights, however, under great limitations, are still cherished in various parts of Germany.

Certain vast areas in America consist of many feet of forest detritus. The fertility of alluvial soil is due, at least in part, to fine particles of humus which have washed from forest regions.

The forest not only enriches the soil, but also is a soil-former. Even the most tender rootlet, because of its acidity, is able to dissolve its way through certain kinds of rock. This, together with the acids formed in the decomposition of humus, is a potent and speedy agent in the production of soil. The roots of many species of trees have no difficulty whatever in penetrating limestone and in disintegrating rocks of the granitic series. As the rock crumbles, soluble inorganic materials are released, which enrich neighboring soils, especially those of the valleys in regions where the forest is relegated to the mountain sides and top, as should be the case in all mountainous regions. In view of the destruction occasioned by mankind, it is a consoling fact that nature, although slowly, is gradually improving her waste lands.

If not interrupted, the barest rock and the fallowest field, under conditions which may be called unfavorable, will become, in the course of time, forest-clad and fertile. The most important function of the forest in relation to the soil, however, is in holding it in place and protecting it from the erosive action of wind and rain.

In order to appreciate the beneficial influences of the forest in this respect, we must study the condition of land which has been for a time deforested. We need not visit the washed lands of the South, where large areas have been ruined beyond redemption. It is visible in every field and in every stream. After a rain a potsherd, piece of shell or pebble may be seen resting upon a pyramid of earth, often over an inch in height. Either the earth of the field has been washed away or compacted to that extent by the beating force of the rain.

A part of physical geography, a subject of great interest and a delightful field for investigation, is the study of those forces which have produced the geographical distribution of forests. Why is it that in one part of the Eastern United States there are vast areas of one or two species of forest trees, in others a mixture of many kinds, in others savanna land, in others desert areas, and in others prairies? The winds, the birds, the fires of the aborigines and countless other agencies have all lent a hand in moulding the surface of Eastern America as it appears to-day.

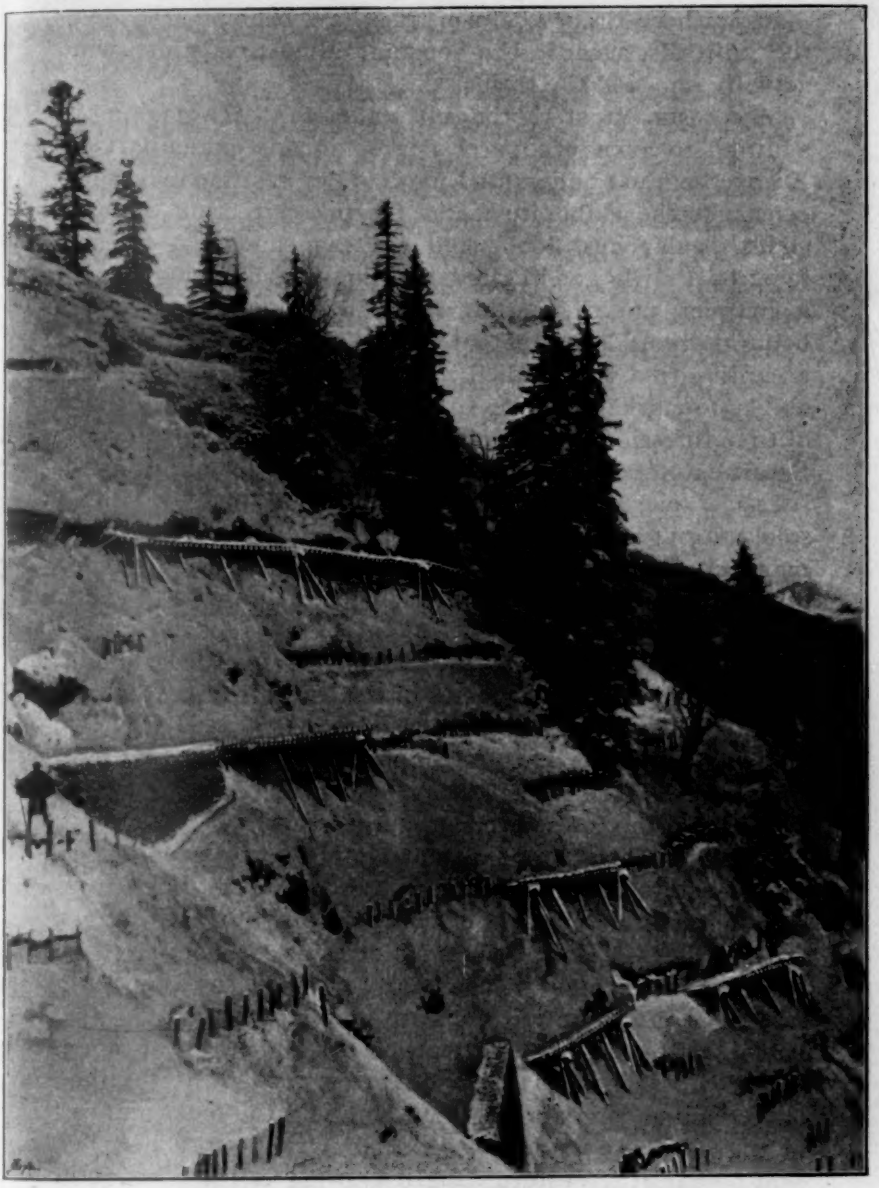
For instance, one tree endures fire better than another, the weakest in that respect in consequence perishes, so that even the species which constitute the forest are, in part at least, due to fires. From the great mixture of trees in swamp lands and in which, owing to dampness, fires have done little damage, we can note all stages to the savanna and prairie lands, which are in part, no doubt, due to fires. It is said that in many parts of the West, when the fires died out with the Indian and the buffalo, forests gradually appeared again. The thousands of square miles of pasturage on the plains and lower hills of Tolima, in South America, were once wooded. Year after year of burning converted this region into pastureland. The trees all perished, with one notable exception—the *Chaparro.* This diminutive tree has been able to survive. It is truly the survival of the fittest. And, so the great conflagrations in the magnificent forests of the Northwest, in our pine forests of the States bordering the Great Lakes, in the forests from Maine to Florida; in fact, everywhere in America where the forests are in combustible

condition, fire is devouring our forestal resources and rapidly changing the nature of the surface of the earth. In regions of dampness the species are manifold, but in dryer portions only the fittest have survived, while in prairie and savanna regions only grasses and sedges are able in the end to endure fire and countless hoofs.

When the forest vanishes there vanish with it conditions of atmosphere and soil which can only be regained by the expenditure of time and energy. Devastation is the matter of a day; reforestation and reclamation mean the expenditure of cash, time and energy.

A forest-road in Baden, Germany.

An important function of the forest is in breaking the force of the wind. On the wind-swept plains of the West even the value of the hedgerow is appreciated. A windbreak of trees is essential to the western farmer. He knows well how the resistless blast robs the land of its moisture, blows down his crops and piles the snow in immense drifts about his buildings. While in Eastern and Western America fires are destroying millions of cords of excellent timber, in the central States they cherish the merest apology of a tree for the protection it affords them, and warm themselves with corn when corn is cheap and coal expensive.



Constructions for the prevention of avalanches in Switzerland.
(Loaned by the Swiss Journal of Forestry)

In southern France belts of trees have been planted along the railroads, because the constant, almost resistless, wind actually impeded the trains.

A forester must thoroughly understand roadmaking in addition to a knowledge of surveying. In many parts of Europe he must understand more of engineering in order to construct the elaborate works foi the correction of landslides, avalanches, floods and shifting sands. A forester must be a fairly good botanist, zöologist and geologist, also a surveyor, and, to a certain extent, a civil engineer, besides being thoroughly competent to manage a tract of woodland according to a well-studied plan, and, in addition, have the ability to market the crop in good shape. The significance of the profession is only fully recognized in parts of Europe. Forest exploitation and road construction go hand in hand, so that inaccessible forest regions become profitable solely through the construction of excellent roads. In Germany excellent stone roads penetrate the forest in every direction, many of which are solely for the purpose of transporting forest products.

During the summer of 1896, in company with Dr. Fankhauser, Government Inspector of the forests of Switzerland, I visited the works of correction in the Bernese High Alps, and was both surprised and impressed with the great difficulty and expense of correcting evils which need not have existed had the forest been properly treated.

In many places by persistent work the Swiss engineers and foresters have prevented whole mountain-sides from slipping and huge masses of rock from crushing the villages in the valleys. Their boisterous streams, which are fed by perpetual snow, must be constantly watched, and the young forests on the mountain sides are in danger of ruin by avalanches. By walls of stone, wattle-work and a host of ingenious devices, they chain these forces until the trees they have planted can gain a footing and hold the rocks and soil in place. There will never be need of such work here, except perhaps in Western America, owing to the absence of precipitous mountains, but there is no better place in the world than Switzerland to study the influence of the

forest in lessening in many ways the destructive forces of nature.

The usual means, and the one employed everywhere for the prevention of avalanches if the depth of soil admits, is the plan of establishing bermen. Bermen are narrow ledges or galleries cut in the soil, beset with rows of short piling forming horizontal terraces. Those stakes are driven as deeply as possibly into the ground and firmly wedged with stones. If the soil is not deep enough for stakes, then the so-called snow-bridges are constructed, which consist of logs or beams supported by solid wooden trestles and running horizontally on the declivity, serving to support the stakes, which are driven as far as possible into the soil of the mountain side.

Together with these constructions in the localities where avalanches take their start, reforestation must go hand in hand so that, in view of the extremely slow growth in Alpine regions, the stakes and snow-bridges may not become rotten and wormeaten before the young forest has grown up sufficiently.

Above the timber line the construction of avalanche barriers is mostly a hazardous undertaking. In such regions the use of lumber is precluded because of its limited durability and other reasons. When it is a question of works to be maintained forever, stone alone is fit. Horizontal walls of dry masonry are built, which present a durable and almost immovable obstacle to the destructive snow masses. These horizontal walls are built one above another, according to the inclination of the slope and nature of the surface. For various reasons even within the timber limit the construction of masonry may be indicated.

Let us consider for a moment the great question of floods, which more vitally concerns us than does the prevention of avalanches by afforestation. "It is unpleasant," says the editor of *Garden and Forest*, "to be constantly sounding alarms and predicting calamities. No gift of prophecy is needed to foretell the ruin which will follow if the devastation of the forests of the Appalachian region from Quebec to Alabama goes on for the next twenty-five years, as it has

done. And who can estimate the destruction which will ensue if the floods are let loose from the still loftier ranges which feed the Columbia, the Sacramento or the San Joaquin, or who can imagine the extent of the inland sea that will roll over the Mississippi Valley when the water barriers are removed from the eastern slopes of the great Continental Divide and the sources of that immense water system in the central north? *Common prudence ought to arouse the Legislatures of the various States and of the nation to face this problem now, which is of more vital importance to the life of the republic than any question of tariff or of currency.*"

With a flood plain of 30,000 square miles, and tributaries draining the immense territory east of the Rockies and west of the Alleghanies, the causes and prevention of destructive inundations along the mighty Mississippi are matters of national interest. Millions of dollars have been spent in the construction of levees, which, although necessary, are second in importance to the preservation of the forests and the afforestation of denuded areas at the headwaters of its tributaries. It is said that Eads after completing the jetties remarked that they had been working at the wrong end of the river.

The difficulty is more a matter of mud than of water. The fact that the river empties into a practically tideless gulf causes the formation of a delta instead of an estuary, and the silt deposited by the flow clogs up its mouth and prevents the rapid discharge of flood waters. Another difficulty is the extremely tortuous nature of the river, which causes strain on certain portions of the levees, and slackens the flow, which in turn causes a large deposit of silt in the river-bed, inevitably in the course of time leading to disastrous consequences.

Before attempts at reclamation, in times of floods the river flowed over the natural levees and deposited a rich covering of mud.

Owing to the deposit of mud in the river-bed, it becomes necessary therefore to elevate the levees until the river at last runs in an aqueduct far above the level of the plain, which is deprived of its former share of mud-deposit. Under

such conditions, in spite of vast engineering efforts to solve the problem and save for cultivation the fertile area of the flood plain, the menace of inundation can, perhaps, never be removed. In former times, before the levees were built, the river in times of flood spread over the natural levees into the vast swamp forest along its shores. There was deposited in this forest, owing to the slackening of the flow, a rich covering of mud. Year after year of vegetal and animal deposit produced the fertility for which the region is famous.

Certainly the construction and care of levees will always be a necessity, and a partial amelioration effected by dredging and straightening the channel, or by any means, in fact, which will hasten the flow and discharge of mud into the Gulf; but even this will all be futile unless equal attention is paid to conditions at the water sources. Forests will not only regulate the waters, but will accomplish something which is more important—they will prevent erosion, and thus materially decrease the amount of silt. In the study of every flood, whether a mountain torrent or the Father of Waters, there are three divisions which must be considered and receive attention commensurate with their importance—they are the collecting area, the channel course and the *débris*. In the case of the Mississippi the collecting area has been neglected.

In the case of a torrent the principal mass of water forms in the collecting area. Here, also, erosion begins—imperceptible in the beginning—but soon an immense volume of water descending on all sides into the channel course. At first it is loaded only with silt; soon in the channel course rocks, stones and timber accumulate. This powerful mass, by undermining the banks, receives constant additions until the whole is dumped into the level plain, when the stream emerges with diminished force. It is a combination of thousands of such streams which forms the Mississippi. In conquering a boisterous stream one can make a series of protective works, or by afforestation retard the flow of waters in the collecting area, the source of the evil. In mountain torrents a series of transverse dams are used, behind which

the *débris* is blocked and the stream prevented from digging a deeper bed. Much could be said of these protective works, which have been extensively constructed in France and Switzerland.

The following is quoted from a speech delivered at a meeting of Swiss foresters, by Dr. Fankhauser, who must be ranked among the highest authority on the subject in Europe:

"Many dangerous torrents have been tamed by engineering efforts, to which a large number of places owe the security of life and property against the devastating force of the elements.

"But the conquest of a torrent by means of engineering constructions alone has also its dark side. Where a simultaneous improvement of conditions regulating the water sources is neglected, constructions, in order to withstand for all time the dashing of powerful floods, must not only be built very solidly but must be maintained continuously in their original condition.

"This point assumes great importance even where stone suitable for the work is easily accessible, because it is a question of using a passive and perishable means to oppose living forces, which are inexhaustible and constantly operating.

"On account of the great cost of building and maintaining these works, it is generally necessary to confine them to the channel course, and to stop here the main sources of erosion. But, as we have seen, erosion begins not here but in the uppermost collecting area.

"The gathering of *débris* is not prevented by the construction, only lessened. Every little side rivulet delivers its quota, and in the course of decades all these washings count up to a considerable quantity. As long as the newly built dams are not filled up, sand and stone are held fast behind them, and the results are satisfactory. But when the levelling process is complete, the brook then pours at flood times its material over the dam as easily or more so than before it was built. From the brooks the sediment gets into the rivers, and these again, when they are treated

in like manner, carry it off into the low lands. As sediment cannot be dissolved by water, it remains where the fall is too slight to carry it further, and causes a raising of the river bed.

"It is easy to calculate what imminent danger ensues to neighboring lands from these conditions, in spite of successive costly raising of the barriers.

"But this is not all. As the river rises the level of the underground water also rises until at last the valuable adjacent fields are converted into marsh land, and expensive drainage canals are made necessary. One work leads to another, and yet affords no permanent relief, because instead of holding the *débris* back among the hills, it is only carried further on, and thus at great expense the trouble is shifted from one place to another, not overcome.

"All technical constructions of this sort only aim at providing a barrier. As the French engineer, Surell, in his famous study of torrents has so aptly said, they are measures of defense, but they do not lessen the power of the waters; they only compel them for a moment to keep certain bounds. Entirely different is the effect of the forest. Of course, it is not a question, as many mistakenly suppose, of foresting the overhanging banks and sides of a torrent to prevent undermining and land slides. A wood is as powerless as the soil itself to resist a torrent, and succumbs with the soil to the rush of waters. But in the uppermost collecting area a forest growth holds the accumulations from heavy rain falls and hail storms, and thus prevents the great and sudden swelling of streams.

"Only reflect that the leaves of a medium aged beech forest, if spread out, would cover eight times the area that the growth in question occupies, and it will be quite apparent that even in the hardest downpours almost one-fifth of the water is intercepted by the foliage, and thence flows slowly down the trunks or passes off in vapor."

Then, too, immense quantities of water are transpired by the leaves, often, as with the eucalyptus, several times the amount which falls on the surface it occupies, in the form of rain.

Shifting Dunes near Avalon, N. J.

Shifting Dunes near Avalon, N. J.

A forest of *Pinus maratima* on the dunes of Gascony.

A large quantity of water is absorbed by the forest floor, and a large quantity runs to the deeper layers of the soil, through channels caused by the decay of roots. A woods is full of stump holes. A torrent to be conquered must be attacked where its forces are scattered and easily controlled.

Before concluding my remarks on floods, I have yet to mention the willow, that Cinderella of trees, which like the mangrove in the salt waters of the South, is the great land-former along the shores of rivers and other fresh bodies of water in northern latitudes. The willow loves to grow even in abandoned land, utilizing a neglected corner or a poisoned pasture, clothing with abundant green the most hopeless fields, moors and marshes, and although covered at times with water, firmly holds the soils of banks, and constantly catches the sediment, thus increasing the depth and fertility of the soil. At the same time its pliant twigs serve for baskets, fences, racks, wagon-bodies, trunks, boxes, etc. Even here its usefulness does not end, since the horticulturists of our prairie regions have discovered that because of its endurance and rapidity of growth it forms an excellent windbreak.

I have still, in conclusion, a few words to say in reference to the fixation of shifting sands. Although the methods employed in France may not be applicable to America, I can show the beneficial influence of the forest in this respect in no better way than in referring to the results of the work in the Dunes and Landes of Gascony, and in order to be brief shall quote on the subject from my report to the State Geologist of New Jersey.

"In the early part of this century the condition of this territory, which is bounded on one side by the rivers Gironde and Garonne, on another side by the river Adour and on the other by the Bay of Biscay, was in brief as follows: There were miles of marshy, treeless land, covered with a low but dense growth of herbage. It was unhealthy, with but few roads and was very sparsely inhabited. Even to-day, now and then, one of the old time peculiar and picturesque shepherds may be seen watching his flocks, standing on stilts, wrapped in a woolly sheepskin coat, knitting

stockings. It was, in short, a desolate, little known and unproductive country. The ground being perfectly level, sandy and underlain with a peculiar hard pan called *alios*, was poorly drained. There was fever in consequence. *Alios* is a sandstone, the cementing material being organic matter and compounds of iron. Near the shore there were salt ponds, fresh lakes and stagnant marshes. Bordering the sea for miles there were huge masses of moving sand called the Dunes. These dunes arrayed themselves in lines along the shores, moving constantly inland, covering villages, filling rivers and clogging inlets. This aggravated the unwholesome condition of the territory in their lee called the Landes. Early writers state that the sandy Dunes and the marshy Landes were both at one time forested, and that this dangerous condition of affairs was the result of imprudent forest destruction. Imagine the dunes along the Jersey shore clogging up the inlets, the water from the interior flooding the marshes and lowlands. The bays, which are now salt, would then become fresh in consequence, stagnation and sickness would follow, and you would have an exact repetition of what happened in Gascony, all of which is described in detail in the works of Chambrelent, Bremontier and Grandjean. The first and most important step was to stop the shifting sand. This was in part accomplished by covering the surface with brush and then sowing the seeds of the maritime pine (*Pinus maritima*), and finally in full by the construction of an artificial littoral dune. When the tide falls the sand of the beach, ground into powder by the waves, dried by the sun and wind, is blown in the direction of the prevailing winds, which is usually toward the shore. The sand moves like drifting snow until it meets an obstruction, and there a dune is formed equal in height to the height of the obstacle. In order to protect the natural dunes which have been sown in pines, an artificial or littoral dune is constructed. This is accomplished in a very simple but ingenious way. A fence of boards or brush is built in a line along the shore a short distance from high-water mark. This stops the sand which is moving inland, so that a drift forms similar to

snow along a hedgerow. When the sand forms a drift equal in height to the fence, so that the fence is in fact buried, a new fence is constructed on the crest of the dune which has just been formed. So on fences are buried and constructed until the dune reaches the desired height, and if lacking in breadth or too wide, the fence is moved back or forward a little to suit the desires of the forester or engineer in charge. By the use of palisades or brush an artificial dune can be easily and cheaply constructed. The dune should have a gentle slope toward the ocean. When the dune has reached the proper size and shape it is necessary to plant its windward slope in *gourbet* in order to hold the sand in place. The *gourbet* or sand sedge has rhizomes many feet in length, by means of which it fixes the sand. This huge bank of sand is constantly watched and kept in shape.

"In traveling along the beach from the mouth of the Garonne to the mouth of the Adour, one sees squads of men and women working on this immense ridge of sand, planting *gourbet* here and there or digging it up in places in order to keep the dune in perfect shape. The vast plantations of pine and the villages in the neighborhood of the dunes owe much to the humble but persistent gourbet. Where were once nothing but huge, barren, shifting dunes are now beautiful pine forests close to the shore of the ocean—the location of several delightful resorts, with the pleasures of the sea and forest combined. Back of the dunes in the Landes, canals and drain-ditches were dug through the impermeable *alios*. Pine seeds were sown, and, through the efforts of engineers and foresters, the region changed to such an extent that a new province was really added to France. The Hugue method of turpentine-orcharding was adopted, the main principle of which is to prevent excessive bleeding.

"With the advent of railroads, forest fires increased, requiring the construction of fire-lanes and the employment of watchful wardens. The soil and people improved, and, thanks to de Villers, Bremontier, Chambrelent and others, the Landes is one of the most interesting and prosperous regions of France.

"Along the coast of America there are shifting dunes. At Avalon, New Jersey, a huge bank of sand is slowly but surely destroying a beautiful forest. It could be stopped at slight expense. These dunes are moving inland over the marshes, leaving their natural beds so that the marsh mud is exposed on the ocean side, and the beach becomes unfit for bathing purposes."

Destroy completely the forest which covers the coastal plain of Eastern America, and it will become a bed of shifting sand, unproductive, unsightly, and unfit for habitation, although capable of producing an abundance of valuable timber.

I have merely mentioned subjects, every one of which would be sufficient for a lecture. It has been my endeavor to show, however, that there is more to the subject of forestry than the mere production of a wood-crop, although, no doubt, out of the American lumbering methods of to-day an American system of forest management will be in time evolved.

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*Stated Meeting, May 11, 1898.*

## GOLD MINING IN GEORGIA.

By Wm. Tatham,
Member of the Institute.

I propose in this paper to give some account of the gold mines and mining in Middle Georgia. Middle Georgia is a sharply rolling country, with few high hills or mountains. In Wilkes County is Graves Mountain, which consists of three elevations rising some 1,000 feet above the surrounding country, celebrated throughout the world for the beautiful crystals of rutile found there, and which are so much admired in almost every mineral collection. Further towards the north, in DeKalb County, about 20 miles from Atlanta, is Stone Mountain, a mass of intrusive granite, which supplies stone for paving blocks and building purposes throughout the South. The climate is temperate. In the summer

the temperature rises to an average of 80°, and in winter it rarely falls much below 32°. In some instances the mercury has been known to drop to zero, but such cases are rare.

The mines I purpose to describe are in that gold belt, sometimes known as the Carolina belt, which extends in a general northeasterly direction through Wilkes, McDuffie, Columbia and Lincoln counties in Georgia, and Abbeville and Edgefield counties in South Carolina. It is on the southern edge of the great belt of Virginia, the Carolinas and Georgia, which was the source of the gold produced in the United States prior to the discovery of gold in California.

The history of gold mining in Middle Georgia dates back to the early part of this century. The Columbia mine in McDuffie County was discovered about the year 1812, and later on, among others, the Parks, the Walker and the Seay mines in the same county, and the Magruder in Wilkes. It is worth noting that, while in North Georgia the first mining was entirely in placers, in Middle Georgia the gold came entirely from vein mining. I know of but two instances in that section where any amount of gold has been taken from surface washings, the Sales mine in Wilkes County, and what is known as the Camp Ground, in McDuffie County. This does not apply, however, to the northeastern part of the belt in South Carolina, where surface washing has been carried on from time immemorial, and, indeed, is to this day a source of income to the residents of the small valleys in the northern part of that State.

The gold occurs in quartz veins, associated with galena, pyrite, chalcopyrite and zinc blende. In some instances these veins are well-defined fissures, but in many cases they are segregations, sometimes very large and persistent, and again an aggregation of small stringers in which the gold is by no means confined to the quartz, but is disseminated in the adjoining rock. Sometimes these deposits are very rich. In the Dorn mine in South Carolina some $300,000 was taken from one rich pocket, and ore which did not yield over $100 per ton was considered poor. It is related of the owner of this property that, seated on his verandah, he would exclaim every time a blast was shot, "There comes

another nigger." A good "nigger" in those days was worth $1,000 to $1,500, which is rather good as the result of a single blast.

The Magruder property, in Wilkes County, is another example. Here there were fissures carrying gold, silver, lead and copper, not apparently varying as depth was attained, and also large segregations carrying on the surface gold only, but which in depth (about 250 feet) carried a mixture of galena and zinc blende, which did not contain sufficient valuable mineral to make their development profitable.

I have smelted quite a large amount of galena from this mine, which ran on an average 40 per cent. lead, 40 ounces silver to the ton and $15 in gold, and some copper not determined. There was a good vein of this ore, but the owner abandoned it to sink, on a segregation, after gold. In general, these segregations consist of a sugary quartz showing gold in the pan and shading off into the country rock. They are sometimes as large as 30 feet wide, and may be traced for long distances; but in the greater number of cases, where they have been followed much below water-level, the ore has turned out refractory and of but little value. There has not been, however, sufficient work done on this class of veins to settle definitely their general character.

The fissures, on the contrary, seem to hold their value in depth. Of course there is less free gold than in the upper portions where the sulphides have been oxidized, but the assay furnace will show about the same amount in gold throughout. I do not mean to say that there is no free gold below water; in veins which I have worked in McDuffie County I have found free gold well below the limit of oxidation—notably in one or two veins where the gold occurred in coarse grains embedded in a mixture of galena and pyrite.

I should mention one peculiarity of the quartz veins in McDuffie County, where I worked. In that locality water-level is found about 40 feet below the surface. At water-level the veins are generally more or less shattered, and contain but little gold, but on sinking a short distance below water they "make again," as the miners say, and attain

their original size and richness. It is an almost invariable rule that a good outcrop followed to water and found almost worthless at that point will repay further expenditure in sinking to a greater depth. There are exceptions both ways —sometimes the vein holds good all the time, and sometimes you do not find the vein again, but the rule holds good.

In my section in McDuffie County the veins almost always show pyrite and galena in the pan whether free gold be present or not.

Before the war, when slavery prevailed, the planters used their hands in mining gold in the intervals between the harvesting of the crops. Some of them kept a trusty negro prospecting for rich outcrops. One old negro whom I knew, spent all his time in this pursuit. If he found a valuable outcrop, he had the promise of a good drink of whiskey, while, on the other hand, if nothing resulted after a reasonable time, he had the certainty of a good whipping. Stimulated thus by hope and fear, the strongest incentives to human endeavor, he made remarkable discoveries, and his owner made, for that country, a great deal of money.

The outcrops thus found were followed to water and then abandoned for new discoveries. While this method of mining was profitable for the planters, it was disadvantageous to their successors. The cream had been taken from all the known ore bodies and nothing was left to guide the newcomers but the remains of abandoned surface workings.

Owing, however, to the rule quoted above, parties with sufficient capital could sink on the old workings with reasonable assurance that the result would repay their outlay, and this is the method of prospecting in that part of Georgia to-day. Of course, the early workers did not discover all of the paying outcrops. There are some still left to make the finders happy, but in my section they are like angels' visits, few and far between.

In the early days of mining in Georgia the mills were of a very primitive description. The stamps were squared pieces of timber armed at the bottom with an iron shoe.

The cam shaft was generally made of wood with projecting pieces which lifted the stamps by striking pegs fitted therein. The motive power was generally water. The mortars were sometimes of iron, but a very convenient substitute was a wooden box filled with pieces of quartz stamped dry, which, when properly worked, formed an excellent bed upon which the ore could be crushed. Instead of screens a plain board was put in front of the mortar over which the water splashed and carried off the finely-ground rock held in suspension. The pulp was run over blankets and the gold thus collected.

In the Columbia mine recourse was had to a number of patented gold-savers, and the fact that the mine was nevertheless successful is sufficient testimony to the value of the property. I had occasion to sample several thousand tons of tailings from stamps at this mine, and although the ore was undoubtedly very rich, I was not able to find more than a very slight value in the tailings, a fact which speaks volumes as to the good practice at that time. In explaining the good work at that mill, the old superintendent said to me: "You know, Mr. Tatham, there was a leather strap hanging up in the mill all the time, and if any of the boys failed to do his work properly he got a good taste of it."

In later days came the iron stamp mill, with plates inside the battery and silver-plated copper aprons, but I question very much if better results are obtained with the new machinery, so far as free gold is concerned, than was had in the old days with the wooden stamp and the leather strap. Of course, much more rock is put through in a given time, but the percentage of yield will be about the same. In those parts of the gold belt, in which placer ground could be worked to advantage, the old-fashioned rocker and long-tom are still in vogue. I have seen them in active operation. The advantages of modern machinery in the South are: (1) an increased production with a given power and number of hands, thus cheapening the cost of milling; and (2) in the improved method of concentration.

The old miners, almost without exception, worked for the free gold in the ore. I say *almost*, because there were some,

a very few, who recognized the value of the sulphides; it was a favorite plan with these people, far in advance of their age, to mix the iron sulphides with wood ashes. The mixture of ashes and sulphides, moistened with water, was allowed to weather for some time and was then put into the mill with the ore. The results are said to have been very satisfactory. Probably soluble sulphates of potash and soda were found together with iron oxide and free gold.

But these pioneers in the chemical treatment of gold ore formed a very small minority. The greater number of gold seekers were content to take the free gold in the ore, leaving the rest to take care of itself; consequently, as soon as the ore presented any difficulty in the way of extraction by simple amalgation, the vein was abandoned for some other surface workings. We have here the explanation of the innumerable surface workings alluded to, and the reason why the work was seldom pushed below water. When the gold remained free, as in some parts of the Columbia mining property, they sank far below water-level.

Twenty years ago gold mining in Georgia was restricted to the remains of the old surface workings and to new finds, but, since it has been discovered that complex gold ores may be cheaply treated, a new era has opened for the southern gold fields.

There is no question as to the amount of gold in the South. We have here a vast territory comparatively unexplored, except that it has been established that there are innumerable veins, carrying free gold to water, and, as a general rule, below water, where the gold is mostly associated with mineral, which makes it impossible to extract the precious metal by the simple process of amalgamation.

In by far the greater number of cases there is enough free gold in the ore to pay for mining and milling, and the value in the concentrates is pure profit. When we have a pure pyrite concentrate we may chlorinate, as is done so successfully at the Haile mine in North Carolina to-day. If we have a mixture of pyrite and galena, we have the choice of the cyanide process, or we may ship our product to smelters, when it can be worked in the lead blast furnaces.

In any event, the gold may be extracted at a moderate cost and with a small percentage of loss.

It is the belief of many well-informed persons that in the near future the gold production of the Southern States will show an increase over that of the past. It would seem as if all the essentials to successful mining were present. Cheap and good labor, a kindly climate and nearness to bases of supply afford conditions which are almost ideal.

There has been no deep mining in Georgia, and it is impossible to say what results may be obtained. So far, however, as our limited observation goes, the facts would seem to justify the expectation that the fissure veins will continue to carry gold in depth, although it may be associated with mineral which will require metallurgical treatment of the concentrated ore, which, however, is no longer the bugbear it was in times past.

Further, in many parts of Middle Georgia the metals lead and copper, associated with the gold, give promise of affording valuable by-products, which will, in many cases, more than pay the cost of freight and treatment at the smelting works.

The concentrates run high in gold. I have had assays of $500 to $600 per ton, and the average of concentrates from several thousand tons of ore taken from the property in which I am interested will be from $100 to $150 per ton; the silver content varies with the percentage of lead in the concentrates. Nearly pure galena has shown 60 ounces per ton.

The ore is not difficult of concentration. The gangue is mostly quartz, and all the mineral in it is worth separating, so that that problem is easy of solution. The Frue vanner, the Embry or the Golden Gate will do the work effectually. For crushing the ore I prefer the stamp mill with amalgamation in the battery, with a sparing use of sodium amalgam. By this method, the free gold saved by first operation will generally be found more than sufficient to pay the cost of mining and milling.

The gold fields of Middle Georgia afford a first-rate oppor-

tunity to persons with the necessary capital and experience. Land and mining rights can be acquired at very moderate prices. Wood for fuel and mining timbers is cheap, and the price of labor, when compared with the western mining wages, is very low.

There have been many failures in this section, but they have been generally caused by a total lack of knowledge of proper methods of mining and milling, or by insufficient capital, or both. But, so far as that is concerned, the whole mining region of the United States is strewn with wreck due to the same causes.

The residents are ready and anxious to welcome parties seeking to develop the resources of the country, and any one who goes down there to do *bona fide* work is sure to be treated with consideration, courtesy and old-fashioned Southern hopitality.

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*Stated Meeting, April 13, 1898.*

## MINERAL RESOURCES OF CUBA.

By Raimundo Cabrera.

Translated from the Spanish by Louis Edward Levy, Member of the Institute.

The receipt of the invitation extended to me by the honorable President of the Franklin Institute of Pennsylvania to present before that widely-famed scientific association an amplification of "Some Notes on the Mineral Resources of Cuba," previously published by me in the *Engineering Magazine*, affected me with two opposing impulses; on the one hand, the consciousness of my inability to do the subject its full measure of justice, and, on the other, my desire to prove my high appreciation of the honor accorded me.

The latter impulse prevailed, strengthened as it was by my natural desire, as a Cuban, to bring to publicity in the industrial centers of this great Republic the incalculable riches which lie in the open lap of my teeming but unfor-

tunate land, ungarnered and almost unexplored, after more than 400 years of European colonization. Thus suggested, my consideration of the subject will avoid a treatment of its technical, purely geologic or strictly scientific aspects, and will be confined to a brief review of data collected from official statistics and from various other competent and authoritative sources, sufficient to indicate the still incipient status of the mining industries of Cuba.

From the time when Cuba first attained any considerable degree of commercial importance it has appeared to the world as a country devoted almost exclusively to agriculture, and even in that branch as limited practically to the cultivation of sugar cane and of tobacco, and to the industrial manipulation of these products. As a source of supply for these two staples, in regard to both quantity and quality, Cuba has commanded universal recognition. But the mineral resources of Cuba, like many other of its rich natural endowments, have been almost entirely neglected, notwithstanding that from the early stages of the settlement of the country, the location and extent of these mineral deposits have been definitely known. Scientific explorations by competent investigators as well as by various industrial undertakings, most of the latter, indeed, tentative and ineffectual, have indicated the existence of these deposits at various points of the island. Quarries of white and veined marble, of granite and quartzites, have, in fact, been developed and worked to advantage, mainly, however, for merely local requirements. But besides these, there are to be found in various parts of Cuba, and only waiting to be developed, many of the most valuable of the metals and minerals of modern commerce. Placer deposits of gold and quartz lodes of silver have been worked in a more or less primitive fashion from time to time, since the days of Columbus. Of other metals and minerals which occur in workable quantity in numerous localities, the following may be mentioned: Copper, hematite, magnetite, manganese, asbestos, sulphur, talc, quicksilver, coal, antimony, feldspar, onyx, serpentine, gypsum, baryta, asphalt and petroleum. Specimens of all these, as well as of a variety of vegetable

resins, were exhibited at the Amsterdam Exposition of 1883, and at the Columbian Exposition in 1893.

The causes which have resulted in the neglect of the mineral industries of Cuba are well and widely known and are of such a nature as to be in detail beyond the purview of the present paper; but it may be stated in general that directly or indirectly the condition is due to the administration of the fiscal system of the country, which, with oppressive tax levies on all industries, on all articles of use and consumption and especially on the importation of machinery and the exportation of products, has barred the influx of extraneous capital and labor while repressing the development of the same at home.

In spite of all this, however, the fifteen years preceding the outbreak of the present civil war saw much material progress in the mining industry of Cuba. This was due to a partial relaxation by the home government, under the pressure of the liberal classes in Cuba, of the restrictions imposed on this industry. The introduction of important, though by no means adequate reforms in the system of taxation which had militated so positively against its development, opened the way in this direction and revealed a wide horizon of possibilities for the employment of capital and labor. Such, for instance, was the law of April 17, 1883, exempting the properties of iron mines from the land tax during twenty years, freeing the ores of iron from export duties and relieving from import duties anthracite coal landed at the mining ports, and destined for use in the mining and metallurgical industries. There still remained, however, the heavy import duties on the machinery and appliances required in the work, as well as the port charges of 50 cents per ton on the ships engaged in the traffic, and these imports prevented that extension of the iron industry which the removals of the other restrictions had seemed to promise.

Four years later (June 30, 1887) the above-mentioned concessions were extended to include the ores of maganese, zinc and lead, but were limited to the workings already registered, all new undertakings being required to pay the land tax.

Later again, by royal decree of July 7, 1892, the Spanish administration retraced its steps and reimposed a tax of 2 per cent. on the gross product of all mineral workings, eliciting the protests of the mine owners that the sanction of the franchises previously accorded had led them to large expenditures on their plants, and that the new impost would compromise them in their foreign contracts. These protests, however, were unavailing; the old tax system was gradually reimposed. The result was that for each hectare (2·47 acres) of area, the mining properties had to pay a tax of $5 per annum, to which was added a surcharge of 50 per cent., making $7.50. In addition to this there was the tax of 2 per cent. of the gross product, amounting to 1 per cent. per ton of iron ore, and 2 cents per ton of maganese, and this, apart from the local municipal tax levies. Thus were thwarted the efforts which were being put forth in Cuba in this important branch of human industry.

THE MINERALS which had been more or less constantly mined in Cuba, up to the outbreak of the present revolution in February, 1895, were the following:

(1) Asphaltum and mineral oils.
(2) Copper.
(3) Iron.
(4) Manganese.
(5) Gold.

The deposits of hydrocarbons, asphalt and mineral oils are extremely abundant and of excellent quality, both for fuel and lighting purposes. They are present in various conditions solid, plastic and liquid, and several experts have affirmed "the existence at a great depth of very light oils, petroleum or naptha." Of these, however, no definite investigations have been made, nor scarcely any examinations beyond such as are incidental to a very primitive stage of industry. On the Motembo estate, Province of Santa Clara, at a location named San Juan, borings were made in 1881, which resulted in discovering, at a depth of 95 metres, a deposit of naptha of extraordinary purity, colorless, transparent as water, inflammable, leaving no residue after combustion, and of a density of 0·754, which congealed at a temperature of 85°

C., dissolved asphaltum and the resins, and which was so volatile that its vapor at ordinary temperature could be utilized as illuminating gas. Nevertheless, this well was abandoned after the workings had reached a depth of 290 meters, although the supply continued at that depth.

A well similar to that at Motembo was discovered at Lagumillas, Province of Matanzas, from which, out of a source at a depth of 25 meters (82 feet) there overflowed a supply of 70 liters (18½ gallons) per day. This also has never been further explored or worked.

In the same Province, at scarcely a kilometer from the northern coast, there exists a deposit of bituminous shale impregnated with asphaltum of a high degree of purity and in great abundance, whose workings, though favored by facilities of transportation, have also been abandoned. But even at the Bay of Cardenas, in the Province of Havana itself, there has been found a similar deposit; this latter appears, from contemporary mollusks and corals embedded in it, to be of comparatively recent geologic age.

In the rocks underlying a large extent of the bottom of this bay are great masses of asphaltum in a liquid state, having in places a thickness of 70 feet, and quantities of this have been carried to market in New York, where it was highly appreciated for its purity, and was sold at prices varying from $80 to $120 per ton. The exploitation of these deposits in the layers at shallow depths was begun with considerable success, but the enterprise languished for want of facilities, and eventually failed entirely through the fatal legislative interference inevitable in that unfortunate country, and the concurrent obstacles which develop in multiplicity under the vicious influence of misgovernment.

Asphaltum is to be found extensively in the Provinces of Havana and Pinar del Rio. In the former, there are being worked the mines of Potosi and Santa Rosa, distant half a league by rail from the harbor of Havana. The deposits exploited are embedded in the cretaceous marls and the serpentines which are met with in the northern districts, the strata running generally N. W. and S. E., in veins of about 6 meters. The material is earthy and impure,

but is advantageously utilized as fuel in grates and ordinary stoves. The mineral is worked in a very crude manner, in the open air, and small quantities of the product have been exported annually. In Pinar del Rio are the Canas and Tomasitas mines, close to the beautiful bay of Mariel. These mines are notable for their size, the veins being 35 feet wide, and from 45 to 90 feet deep. They produce over 1,300 tons annually, destined for the use of nearby plantations, whose owners combine in working the deposits, the operations all being carried on in the open air. Asphaltum, or "*chapapote*," as it is called in the country, is very abundant in the Vuelta Abajo, where it commonly occurs spread on the ground as it has been disengaged from the rocks. There are many smaller workings, among them, that of Santa Helena, at Bahia Honda, which district contains unworked deposits of an asphaltum of great brilliancy and purity, which would doubtless be greatly appreciated in the market.

COPPER has been mined on a larger scale than any other of the mineral resources of Cuba, particularly in the Province of Santiago de Cuba, where it was extracted in large quantities until the disturbances of the revolution of 1868 put an end to the industry.

The town of Cobre takes its name from the adjacent mines, which attained celebrity for their great richness and which were worked by a corporation known as the "Consolidada," with a capital stock of £40 sterling per share. These mines were discovered about the middle of the sixteenth century, but their working was reserved for itself by the Spanish Government, with the result simply of their being given over to various contractors, who, without capital or security, sought to profit by them without accomplishing more than keeping more competent agencies from attempting the work. Subsequent to 1833, and after much tribulation and expense, the Consolidado Company discovered some large and profitable lodes, and this not only gave that enterprise a great impetus, but also stimulated the inception of competing enterprises, one of which undertook the development of a number of mines, under the owner-

ship of an English syndicate, with a capital of $300,000, and named the Santiago Company.

The mines of Cobre, of which the machinery and outfittings were destroyed by the insurgents during the so-called Ten Years' War, and the workings wholly abandoned, were subsequently acquired, during the succeeding interregnum of peace, by the Cobre Railroad Company, which energetically undertook the re-establishment of the plant. The company constructed five iron bridges, equipped the workings with tramways, rolling stock and locomotives, importing the material requisite for the purpose, but the efforts thus put forth remained unproductive, and the enterprise was practically abandoned, not by reason of any deficiency in the mines themselves, whose great productiveness is widely known, but solely because of the obstacles created by the administration and by the difficulties with which every enterprise in Cuba is overwhelmed in a struggle for existence against the insatiable hydra called "The Revenue." The exploitation of the mines has dwindled to a reworking of the tailings of the early rich outputs in the mounds of *débris* which cover the ruins.

Other veins are being worked in a more or less primitive way, utilizing the waters which filter from the cavities of former workings, precipitating the copper by means of iron and thus obtaining the copper in a refined state. Of this product 700 quintals were exported in 1885.

The cupriferous zone of Santiago de Cuba embraces three divisions; the district of Coney that of the Cauto and the district of Cobre. The two former remained unworked; the owners of the mining rights appear to be content to preserve their franchises awaiting better times, having assured themselves of the existence in their concessions of rich veins of native copper, and of its sulphides, oxides and other forms.

According to the able report of Señor Salterain, "quite superficial diggings have disclosed a ferrugineous ridge of 8 meters width, traversed by veins of copper sulphide, copper oxide, carbonate of copper, copper pyrites and native copper, all the veins rich in mineral contents, and which at bottom are probably joined in a single lode of copper sul-

phide, as suggested by a study of the mines of La Caridad, opened in 1882, of those of Portes and others, and of the associated minerals."

In the province of Santa Clara mining concessions have also been allotted, notably at Malejas and at Nicaragua, which have been superficially worked, and which both Spanish and foreign investigators have pronounced as of great importance and promise. Finally, in the provinces of Mantanzas and of Pinar del Rio, considerable copper deposits have been found, the mining of which, occasionally attempted by some crude worker, was always very soon abandoned.

To sum up, I may say, with regard to this subject, that while the discovery of veins of copper has proceeded with great activity in Cuba, as is evidenced by the large number of mining concessions which the Government has granted to individual proprietors (of whom in the district of Cobre alone there are more than fifty), this activity has been due primarily to the facility with which the deposits have been found. Furthermore, however, the general inactivity in exploiting the concessions has been caused directly by the public administration, in a country overburdened with onerous imposts on even the most minute details of industry. The land itself is a veritable mine of wealth, whose productivity is exhausted by the implacable voracity of the tax gatherer. No further comment is needed than the fact that in 1881 the export of copper amounted to only 35 tons.

IRON: Nature appears to have endowed the Province of Santiago de Cuba with its greatest gifts of mineral wealth, and as in the case of copper so likewise in that of iron, the most extensive deposits are found in that province. Large masses of hematite and of magnetite are there to be found, of which a number of deposits extend eastwardly at distances of from 12 to 50 kilometers from the city of Santiago, and about 6½ kilometers from the coast. Numerous mining concessions have been granted in this vicinity, divided into some sixteen groups, named respectively from the towns around which they centre; but, of all these concessions only three are being actually worked, and these by an American

corporation, the Juragua Iron Company. This concern has undertaken operations of genuine importance in the mines named Juragua, not only as regards the mining itself, but also in the transportation of the mineral to the coast and the shipment of the ore at the wharves. For this purpose a railroad, several bridges and extensive wharves have been constructed at a point called Cruz, on Santiago Bay, where the ore is loaded into vessels carrying about 2,500 tons.

The success attained by this Company, whose output has grown from 21,798 tons, in 1884, to nearly 350,000 tons in 1893, stimulated the inception of other similar enterprises in the district of Santiago de Cuba, but though on every hand the bowels of the earth were fraught with a rich store of mineral wealth, and its surface teeming with fertility, the proprietors of the many concessions which were sought and obtained, following the examples of the owners of the copper mines, have been content to guard their rights and to retain their holdings in the hope of a better governmental system, under which capital and labor would be attracted to the task of wresting its stores of wealth from the lap of this prolific yet unhappy land.

A number of other corporations like that of Juragua have been organized by foreign capital, notably the Spanish American Iron Company, which has undertaken the building of a railroad of 6 kilometers length to the mouth of the Diaquiri, and the establishment by dredging and other works, of an artificial port at that place, and the Sigua Iron Company which has begun the working of several mines in the group of Arroyo de la Plata. The total exportation of iron ore from Santiago, since the mines were opened in 1884, has been upwards of 3,000,000 tons.*

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* Through the kindness of Mr. John Birkinbine, the President of the Franklin Institute, I am enabled to add the following detailed data regarding shipments of Cuban iron ores.

The Juragua Iron Company, limited, was the initial producer of iron ore in the Santiago District, its first cargo being sent forward August 7, 1884. The Sigua Iron Company did not ship any ore until October, 1892, and the Spanish American Iron Company made its first shipment, May 27, 1895.

The production of each of these companies has been as follows:

MANGANESE also is extremely abundant in Santiago de Cuba; numerous claims for the mining of this mineral have there been located, and a few of them recently put into operation. At Alto Songo veins of manganese dioxide (pyrolusite) are developed to a considerable extent in red jasper and metamorphic formations.

The mineral sites of Santa Margarita, Isabelita, Bostoyo and other localities, have revealed important deposits, though but slight effort has been given to develop them. The most notable workings at the present time are those of Cristo and of Ponipo.

In general the manganese deposits are worked by the people, who take them under lease from the proprietors, paying a royalty of so much per ton. Thus the mining of this mineral, so esteemed as to have been awarded a gold medal for its quality at the London Colonial Exhibition, proceeds on but a trifling scale, being furthermore restricted by the difficulties of transportation, which is mostly by means of wretched ox-carts over miserable roads. Everything is incipient, everything primitive. Many important mines have had to be abandoned simply because of the cost

| Years. | Juragua. Tons. | Sigua. | Spanish American. | Total. Tons. |
|---|---|---|---|---|
| 1884 | 21,798 | — | — | 21,798 |
| 1885 | 81,106 | — | — | 81,106 |
| 1886 | 111,710 | — | — | 111,710 |
| 1887 | 97,711 | — | — | 97,711 |
| 1888 | 198,040 | — | — | 198,040 |
| 1889 | 256,278 | — | — | 256,278 |
| 1890 | 362,068 | — | — | 362,068 |
| 1891 | 266,377 | — | — | 266,377 |
| 1892 | 322,527 | 7,830 | — | 330,357 |
| 1893 | 348,663 | 14,022 | — | 362,685 |
| 1894 | 150,440 | — | — | 150,440 |
| 1895 | 311,053 | — | 74,991 | 386,044 |
| 1896 | 298,299 | — | 114,101 | 412,400 |
| 1897 | 244,817 | — | 206,812 | 451,629 |
| Total . . | 3,070,887 | 21,852 | 395,904 | 3,488,643 |

In addition to the amounts given above for the Juragua Iron Company, limited, which represent the imports, four cargoes of 10,131 tons were lost at sea.

of transportation to the place of shipment, though over but a short distance, made the product unavailable.

The manganese exported up to 1891 amounted to 34,308 tons, which obtained in the United States a price ranging from $10 to $14.35 per ton, according to its composition.

GOLD which abounds in the provinces of Santa Clara and Santiago de Cuba has not, up to the present time, afforded any contribution to the public wealth or general industry of Cuba. All the various scientific explorations and individual prospectings which have demonstrated the existence of important veins of this metal have resulted in nothing, for lack of capital and means of operation, which are ever shy of undertakings in a country where the political unrest which has produced throughout the century such numerous catastrophes, has made all enterprise insecure.

In the district of Placetas, near Guaracabuya, there are a number of mineral sites of importance. Senor Fernandez de Castro, Civil Engineer, in a notable paper published in 1865, states as follows:

"In the mine of Guaracabuya the serpentine, which constitutes the subsoil, appears mottled with irregular veins, some of them quite marked, in which at a glance may be seen the particles of gold, disseminated on the surface in minute scales or nodules more or less connected." In 1865 explorations were renewed to determine the extent and depth of the gold lodes in Guaracabuya, and according to the report made by Senor Saltarain, mining engineer, these investigations indicated the existence of three distinct lodes. But the workings begun were soon abandoned, not only for lack of adequate means and appliances, but furthermore by reason of the revolutionary convulsions that began in 1868 and continued throughout the ten succeeding years.

A similar fate befell the mines of Las Meloneras and of El Descanso, in the same province, and those of Holguin, in the province of Santiago de Cuba. At the latter place, according to the reports of Señor Fernandez de Castro, of Leon Owen, an English mining engineer, and of other experts, there exist a number of gold deposits, among them that of Monte Verde, in the Guayavales section, where there

are three veins that have been worked in former generations. These reports indicate that this region contains a number of separate auriferous lodes, which appear to afford assurance of continuance to a considerable extent and depth.

The value of the gold deposits in the island of Cuba has long been recognized. Several remains of ancient workings have indicated that these deposits mere mined by the aborigines; historians of the discovery of the island have noted the gold ornaments which the natives presented to the Spaniards, whom the quest for gold attracted with greater avidity to the neighboring continent, in Mexico and Peru, where they found it, mined and worked in more dazzling quantities, in the hands of the subjects of Montezuma and the Incas; but certain it is that while unfortunate Cuba retains rich veins of gold in its unexplored soil, its people have not yet seen a single coin of the precious metal obtained from that store.

Perhaps the future reserves for them a happier time!

Besides the quartz veins referred to, there are to be found in the bottoms of ravines and mountain glens alluvial or placer deposits of gold in considerable quantities. It has been stated that Don Vicente Guillem, jeweller of Holguin, with a single day laborer, obtained from these deposits gold sufficient for the requirements of his workshops.

Mines of various other minerals exist in Cuba, of which more than a brief mention need scarcely be made. Sixty kilometers distant from Santiago de Cuba, there is a group of ten mineral sites spread over an area of some 4,000 acres, the property of Don Julio Aurich, the mineral from which contains 34 per cent. of iron and 28 per cent. of manganese; these deposits are not worked. The mineral limonite (hydroxide of iron) is found in various deposits disseminated in Baracoa, where it has been discovered in strata in the ridges bordering the seashore.

Chrome iron is also to be found in the same district of Baracoa, where three mining claims have been taken up. The analysis of the mineral from the Valhourat Mine, made in the Paris School of Mines, showed the presence of chrome

oxide to the extent of nearly 58 per cent. Other mines of this mineral have been located at Mayari and at Sagua de Tanamo, in both of which localities it is very abundant. In Bayamo, in the precinct of Vavecito, there is a tract of 84 hectares (170 acres) of lead ore, and two other sites of this mineral in the same vicinity show veins of some 50 centimetres width, an analysis of which indicated the following:

| | Per Cent. |
|---|---|
| Lead | 46 |
| Zinc | 14·34 |
| Silver, per ton | 19 oz. |
| Gold, per ton | 3 oz. |

Of this mineral specimens were shown at the Chicago Exposition.

In the district of El Cobre, precinct of Sevilla, there is a deposit of argentiferous lead covering some 150 acres. The analysis shows the following:

| | Per Cent. |
|---|---|
| Lead | 45·73 |
| Sulphur | 16·45 |
| Silica | 10·38 |
| Silver | 0·39 |

Of this class of mineral sites numerous mining claims have been taken up, all of which remain unworked.

Of asbestos, two mining concessions have been granted at Mayari, both covering 120 hectares (300 acres). This mineral also appears in abundance at Holguin, in the Nuevo Potosi gold mine, where it is found in fibres 20 centimeters long.

Of guano, immense deposits exist in the caves of Cuba. In one cave of the Cantivar group, on the south coast of Santiago de Cuba, the property of the Guimera Company, there is a deposit of from 4,000 to 5,000 tons, and the other caves are estimated to contain fully 70,000 tons. This company has built a railway to handle the product, which has been sold in New York at a price of $7 per ton. Its cost for labor, carriage and transportation was figured at $6.15 per ton.

An analysis of this guano gave the following:

| | |
|---|---|
| Water | 35·75 |
| Potash | 0·05 |
| Ammonia | 0·55 |
| Phosphoric acid | 19·60 |
| Phosphate of lime | 42·98 |

The granites and marbles of Cuba have also been worked to a limited extent. In the adjacent Isle of Pines, off the southern coast of the Province of Havana, the quarrying of some remarkably fine marble, both white and veined, was undertaken, and the product was regarded by experts as equal in quality to that of Carrara and of Mexico; but the enterprise failed almost in its incipiency for want of laborers, as well as of means of carriage and of transportation to market.

CONCLUSION.—When it is remembered that in the Island of Cuba, where the production of sugar reached, in 1895, the fabulous amount of 1,100,000 tons, and where nevertheless, this industry became ruined; where only a fifth of the available land has been turned by the plough and the other four-fifths remain fallow, the fertile ground untouched by seed and given over to nature; when all this is considered, it is not at all astonishing to find that the mining industry has been unable, even with intelligent and earnest effort, to utilize the incalculable wealth beneath the soil.

There, where the mines are all of them at but a short distance from the coast, and from havens offering easy means of shipment; where numerous inlets, streams and other water ways afford abundant facilities for transit; where neighboring woodlands yield plenty of timber for building and other purposes; where the rigors of winter are never felt, and where snow is not present on even the highest mountain peaks; where the heat of the tropics is mitigated by cooling breezes from the ocean and where, in short, nature appears to have fairly poured its stores into the hands of men, there neither immigration nor capital take part, though neither would have remained indifferent to such attractions had there been an assurance of aught else than that, in the midst of all these natural resources, a due recompense for energy and effort could not be had.

What Cuba has lacked and still is lacking, is that which is the condition precedent to any development of population and of wealth; a condition of political stability, one with which the people are in harmony, which affords to the citizen, to the immigrant and to capital, freedom and security.

NEW YORK, 72½ Irving Place, March, 1898.

## APPENDIX.

The mining claims located in the island of Cuba up to 1891 were as follows:

| | | | | | |
|---|---|---|---|---|---|
| Iron | 138 | claims, | covering | 7,737 | hectares.* |
| Manganese | 53 | " | " | 4,015 | " |
| Copper | 5 | " | " | 1,160 | " |
| Gold | 5 | " | " | 232 | " |
| Asphaltum | 1 | " | " | 60 | " |
| Zinc | 3 | " | " | 99 | " |
| Lead | 2 | " | " | 166 | " |
| Quicksilver | 2 | " | " | 27 | " |
| Chrome iron | 1 | " | " | 56 | " |
| Coal | 2 | " | " | 115 | " |
| Antimony | 1 | " | " | 60 | " |

* A hectare is equal to 2'47 acres, approximately 2½ acres.

Following is an analysis of the Juragua iron ore:

| | Per Cent. |
|---|---|
| Iron peroxide | 95'15 |
| Silica | 1'90 |
| Carbonic acid | 0'98 |
| Alumina | 0'55 |
| Lime | 0 67 |
| Magnesia | 0'15 |
| Manganese oxide | 0'50 |
| Sulphur | 0'07 |
| Titanium | 0'03 |
| Organic matter | 0'00 |
| | 100'00 |

Manganese was exported as follows:

| | Tons. |
|---|---|
| 1888 | 1,942 |
| 1889 | 704 |
| 1890 | 21,815 |
| 1891 | 9,847 |
| Total | 34,308 |

An analysis of the ore from the Sigua copper mines gave the following result:

| | PER CENT. | | | | |
|---|---|---|---|---|---|
| Copper | 48·70 | 41·32 | 40·78 | 47·31 | 48·31 |
| Iron | 0·70 | 3·46 | 4·75 | 2·35 | 2·74 |
| Sulphur | 3·88 | 4·21 | 5·28 | 0·88 | 1·34 |
| Silica | 25·13 | 31·42 | 33·28 | 28·37 | 27·38 |

An analysis of the ore from the manganese mines of San Luis showed the following:

| | PER CENT. | | | |
|---|---|---|---|---|
| Manganese | 46·130 | 46·03 | 47·37 | 46·70 |
| Iron | 2·986 | 2·840 | 2·62 | 5 89 |
| Silica | 10·490 | 9·580 | 8·53 | 13·38 |
| Water | 6·614 | 6·743 | 7·35 | 11·34 |

## DISCUSSION.

MR. E.V. D'INVILLIERS:—The very interesting paper just read is almost too general in its statements to be subject to discussion; but it appears to me that more stress might have been laid on the really excellent deposits of specular iron ore and manganese in the province of Santiago de Cuba, from which very large shipments have been made to the United States. Of course, during the distress consequent upon the present military operations, the exploitation of these deposits has been largely confined to the companies already established there, the chief of which are the Juragua and Spanish-American Companies.

The Sigua Iron Company, whose mines and plant lie about twenty miles east of the town of Santiago de Cuba, is now in the hands of receivers, and has not proved a commercial success since its incorporation in 1890, the ore deposits soon becoming too lean to warrant profitable shipments.

Why this is so it is somewhat difficult to say, and there is still an undercurrent of hope, if not of belief, that additional investigation on other portions of their large estate of some 40,000 acres will lead to the location of larger and better deposits of commercial iron ore. Indeed, but for the present war in Cuba steps might have been taken before

this to thoroughly prospect this property, and as the company owns such a large acreage of land covering the same range as that which has produced such large quantities of ore at the mines of the two other companies, it would seem not unreasonable that such development might lead to satisfactory results.

An unusually large number of experts, furnacemen and miners have visited and reported favorably upon this property, both prior to the purchase of the estate in 1890 and since actual operations were begun, and it seems strange that the attractive surface outcroppings should not have yielded a more stable and higher grade deposit of ore.

In this connection it might be stated that the Juragua Company has also passed through its periods of great uncertainty as to an ore supply, and that some of the richest and largest lenses of ore they have obtained showed absolutely no surface outcrop.

All the ore mined from this range, extending for about twenty-two miles east of Santiago de Cuba, is a red hematite of excellent quality, furnishing an ore with over 60 per cent. of iron and well suited for the manufacture of Bessemer pig.

As before stated, the manganese deposits to the north of Santiago de Cuba, at El Christo, as well as the old Cobre copper deposit to the west of the town and bay, are well worthy of mention and further examination. The reference to coal in Señor Cabrera's paper is of the first importance to the future of Cuba; but as yet I do not think its commercial character and occurrence have been sufficiently established to merit its recognition as one of the staple industrial products of this beautiful island, so rich in its varied natural resources, climate and soil, but so unhappy in its political government and history.

PROF. F. LYNWOOD GARRISON:—In view of the probable cessation of Spanish rule in Cuba with a subsequent indirect or direct government under American influence, the paper by Mr. Cabrera is peculiarly appropriate at this time, and, although he treats the subject in a very general manner, it contains a number of interesting statements which deserve

careful consideration. When we remember it was the greed for gold that underlaid and gave the strongest impetus to the original Spanish exploration and colonization of the American Continent and its adjacent islands, it is certainly remarkable that, after centuries of settlement and civilization, so little is known of the mineral resources of the interesting island of Cuba, located on the very threshold of our great commercial and manufacturing centres.

That these mineral deposits are of considerable importance and value there can be but little doubt, but it is well to remember, in this connection, the tendency of the human mind to exaggerate the unknown, the hidden and buried wealth of an undeveloped mineral territory. This disposition—the essence of speculation—is latent in the minds of even the most conservative and careful men, and is one of the most difficult tendencies a careful mining engineer has to overcome in order to arrive at a safe and fair estimate of the undeveloped mineral resources of a new country. Nothing in the history of mining enterprises is more common than an over-estimation of their commercial value, and nothing is so disastrous to the country itself and to a healthy growth of its legitimate mining and metallurgical industries.

In the present instance it is well to accept with due conservatism any statements relative to the unknown or undeveloped mineral deposits of Cuba. Doubtless many localities will be found to be very rich, but it does not follow that they will all prove commercially remunerative. The value of an ore deposit depends not so much upon the inherent richness as upon a variety of economic conditions affecting its availability in reference to transportation, supply and quality of labor, fuel, timber, etc.; all these and other factors must be carefully considered if we are to develop successfully a mineral deposit of any description, however rich and wherever located.

During the reconstruction days, after the close of the present war, nothing possibly could be more disastrous to a healthy and successful development of Cuba's mineral resources, or, in fact, any of its latent wealth, than a boom

and an era of speculation. Fictitious values would be created, the money of innocent and confiding investors would be squandered, dissipated, and the country obtain an undeserved bad name, not soon to be eradicated.

The first observations of any value upon the geology and mineral deposits of Cuba were those of Alex. von Humboldt, some fifty or more years ago. Since his time there have been few publications upon the subject, and, as far as I know, none of much scientific merit, and few of practical value.

According to Humboldt, nearly four-fifths of the island is low and its surface covered with "secondary and tertiary" formations, through which granite and other eruptive rocks protrude. The highest elevations are in the southeastern portion, where a ridge known as Sierra del Cobre reaches an altitude of some 7,500 to 8,000 feet. He states that the central and western parts contain two formations of compact limestone, one characterized by the presence of a sandy clay, and the other by gypsum; the first he believes to be Jurassic. East of Havana, he states, the secondary (*sic*) formations are traversed by syenite and other plutonic rocks; on the southern, as well as in the northern side of Havana Bay, jurasic limestone is found. Going south, towards Gla and Guanabacoa, no syenitic rocks are found, the entire surface appearing to be serpentine. This latter rock is much fissured, is of a bluish-brown color, covered with manganese stains. Near Guanabacoa, serpentine is found traversed by quartz veins, amethyst, chalcedony, etc. He says that he could find no evidences of gray argentiferous copper, commonly reported as occurring in this formation. Petroleum exudes at this locality through fissures in the serpentine. It also occurs with other bitumens near Havana and at Holguin and Mayari in Santiago de Cuba.

I give a few of these observations of Humboldt's for what they may be worth. In more recent years, with the exception of the copper deposits at Cobre, as far as I am aware, the only important developments have been in the iron ores and the manganese deposits of Santiago de Cuba Province.

The copper mines of Cobre appear to be among the first,

if not the very first, of the mineral deposits of Cuba that were worked to any extent. It is supposed they were originally developed in 1524 by the followers of Velasquez, and in 1550 were operated by a German named Tezel. Some of the shafts sunk in these deposits reached a depth of several hundred feet when operations were abandoned some few years ago. This would tend to show that the deposits must be quite extensive and possibly rich. The low price of copper ore compared with twenty years ago, together with the inherent difficulties incident to successful mining in Cuba have doubtless led to their abandonment. Iron, manganese and bitumens (asphalt, etc.) will probably be the products most advantageous and profitable yielded of Cuba in the near future, peace and good government being once assured and maintained. Let us earnestly hope that the day may not be far off when the mineral riches of this unfortunate and stricken land will respond to the talismanic touch of capital and energy, that its rocks may pour forth their treasures to the benefit of mankind.

## CHEMICAL SECTION.

*Stated Meeting, Tuesday, December 21, 1897.*

### THE TECHNOLOGY OF CALIFORNIA BITUMENS.

BY S. F. PECKHAM.

The late publication of a paper, in which Prof. C. F. Mabery describes certain researches upon California petroleum, leads me to put on record what has been done upon the technology and chemistry of California petroleum in the thirty-two years that have elapsed since 1865.*

Prior to that date a reconnoitering party, accompanied by Prof. Benj. Silliman, Jr., had visited Southern California and had examined the deposits found in the valleys between Los Angeles and Santa Barbara. On his return to the East, Pro-

* C. F. Mabery, *Am. Chem. Jour.*, **19**, 796.

fessor Silliman made reports, based largely upon personal opinions, that were very widely circulated, but which, subsequent events proved, were based upon erroneous conclusions. A potent factor in the formation of these opinions was an examination of samples of oil, made by several distinguished chemists, which samples were afterwards proved to have been grossly falsified.*

Meantime, two companies, with vast resources on paper, purchased two large tracts of land and equipped and sent out to Santa Barbara and Los Angeles counties a corps of superintendents and engineers who were expected to develope a petroleum region that should rival that of Pennsylvania. The California Petroleum Company operated on the Ojai Ranche, north of Ventura; the Philadelphia and California Petroleum Company operated on the Simi, Las Posas and San Francisco Ranches, farther east; in the cañons of the Sulphur Mountain the Hayward Petroleum Company and Stanford Brothers were obtaining petroleum from pits and tunnels, and in the mountains west of the San Fernando Pass several parties were obtaining dense petroleum or light malthas in like manner. A small refinery was in operation on the San Francisco ranche, but the larger part of the oil produced was obtained from the cañons of the Sulphur Mountain, and was sent up the coast to refineries on San Francisco Bay.

During the summer of 1865 Drs. John Torrey and C. T. Jackson had visited the Ojai Ranche, and had made a report that to some extent confirmed the statements made by Professor Silliman. The last-named gentleman had also made experiments in Boston upon some of the "surface oil," so called, from Santa Barbara County. The oil or maltha was obtained from the Ojai Ranche, and when "cracked" yielded a distillate equal in volume to about 60 per cent. of the crude maltha, that when treated was pronounced a fair quality of burning oil.

In June, 1866, I made a reconnoisance of the region and prepared a report for the State Geologist of California, in which I showed that, in the ten months preceding, 2,448 barrels of

* B. Silliman, *Am. Jour. Sci.*, II, **39**, 341; S. F. Peckham, *ibid.*, **43**, 345.

crude oil had been shipped to San Francisco, while the remainder of 7,000 barrels was allowed to run to waste. Very little merchantable oil was made from this crude. I took a number of samples with me when I left the Pacific Coast, and I subjected them to a series of experiments, the results of which may be summed up as follows: Distillation under pressure produced a fair yield of illuminating oil, which had a fine appearance but did not burn well. There was also a fair yield of lubricating oil of good quality. I also made an ultimate analysis of some of the California oils, and showed that they contained nitrogen and sulphur, and that the percentage of hydrogen was low.

My conclusions were thus stated, that "the best refined petroleum that I have made, either in California or at the East, as also the best that I have seen from other sources, fails to produce a light of such intense whiteness as the best refined Pennsylvania oils. It is my opinion that this difference is due to admixture of the 'benzole' series, or, perhaps, some other, containing a large amount of carbon in proportion to the hydrogen, in such quantity as to render the combustion incomplete, and thus produce a yellow flame."

The reports that I made to the State Geologist of California were unfortunately involved in the catastrophe that overtook the survey, and were not published until 1882, and then in a very limited edition, as Professor Whitney expressed it, "to furnish copies for the learned societies." In these reports I insisted that Southern California had veritable oil interests; that the crude oils were totally unlike those of Pennsylvania, yielding peculiar products of manufacture, and that no more inviting or promising field for chemical and technical research could be found than these bitumens present. In closing my last report (January, 1871) I made use of the following language, "The vast accumulation of the raw material in the southern counties, which though proved of but little value in its application to purposes and processes at present well known, is, nevertheless, an immense storehouse of material force, which only needs to be studied to be found of the greatest value as a source of fuel, if nothing more. It must constantly be borne in mind that this

variety of bitumen is essentially a new substance of unknown applications, which may be discovered either by research and comparison with other and better-known varieties or by the longer, more laborious and expensive process of empirical experiment." Professor Whitney was so far impressed with the importance of these facts that, during the last year of the Geological Survey, plans were perfected by which I was to spend a couple of years in the laboratory of the University of Berlin in conducting these researches. These plans were also involved in the wreck of the Geological Survey.*

For a number of years California bitumens attracted little attention. At the time I prepared the report on petroleum for the Tenth Census of the United States, I could not convince Gen. Francis A. Walker that there were any petroleum interests in Southern California that would warrant the expense of an investigation and report. In this conclusion he was mistaken, as at that time a large number of productive wells were in successful operation in Ventura County.

About 1890 or 1891, the different interests in the neighborhood of Santa Paula, Ventura County, consolidated into the Union Oil Company, of California. This company built a refinery at Santa Paula, and soon after called Dr. Frederick Salathé to assist them in the technology of the various oils that were received at the refinery from the different wells in the vicinity. The Pacific Coast Oil Company, which was operating farther east in Los Angeles County, always had an advantage in the business of refining, inasmuch as their crude oil was lighter in specific gravity and yielded a larger product of light distillates, which commanded a more ready sale than the heavy ones. Their refining had always been done at Alameda Point, in San Francisco Bay, to which place the crude oil was shipped in tank cars.

Dr. Salathé had entered upon his work at Santa Paula with a laboratory well supplied throughout except in one particular —there was no gas in that part of the country, and alcohol and gasolene were poor substitutes for gas, which has become

* S. F. Peckham, "Reports Geological Survey of California," Geology, ii, Appendix, 49-90.

almost an absolute necessity with modern methods and apparatus. His technical apparatus left nothing to be desired. He had also entered upon his work with the understanding that he could convert a large part of the California bitumen into benzole, and thus inaugurate a profitable technology. I have been informed that the Pacific Coast Oil Company had had their crude oils fractionated with results that showed a large proportion of the series $C_n H_{2n+2}$. Dr. Salathé professed to have reached similar results with the Santa Paula oil, and to have solved the same problem that he had solved when he converted Pennsylvania petroleum into benzole.

There were other problems to which Dr. Salathé gave his attention. He had extracted the bitumen from the Turrellite of Texas and called it Lithocarbon. It proved to be a sulphur bitumen. He had treated the asphaltic residuum of California petroleum with sulphur and called the product Petrocarbon. He also oxidized one of the California distillates for use as a basis of printers' ink and called that Linolith. He re-invented the use of caustic lime instead of caustic soda in the treatment of distillates, a process first used by Selligue about seventy years ago. He also invented a process for treating lubricating oils by diluting them with naptha, and then, after treatment, distilling off the naptha. After Dr. Salathé had been with the company about a year and a half and had applied for patents on all of these processes, I was asked to visit Southern California and help Dr. Salathé get these numerous patents through the Patent Office. After I had been engaged in this work for some time I was informed by Dr. Salathé that he had discovered that the crude oils and their distillates contained nitrogenous basic oils, and we at once set about contriving methods for removing them from the distillates, thereby improving the products in various ways. After a time Dr. Salathé left the employ of the company and I was placed in charge of the refinery, in addition to other work.

The refinery was, for the most part, one that had been originally set up in Pennsylvania and had been taken down, carried to Santa Paula and reconstructed. It was at first operated profitably on very crude and cheap products, but it was found

wholly inadequate to meet the demands of a market rendered fastidious by the highly-finished output of eastern refineries, and especially when required to treat such a variety of materials as finally passed through it. It was also used as a loading station for a large amount of heavy fuel oils.

The crude oils used in the refinery were of different colors, from green to black, and of specific gravities ranging from 20° to 35° B. These oils were distilled to a variety of residuums that differed in consistency from heavy oils or tars to brittle solids. There were made five grades of solid asphaltic residues, a dense paving flux that would scarcely flow, a more fluid paving flux and a reduced green oil called "skid oil," that was used to grease the skids in the lumber districts up the coast. From the distillates from these residues were made gasolene, naphthas, gas oil of 40° B., an oil of 28° B., and several grades of lubricating oil, light and heavy, treated and untreated.

The three stills were connected with condensers that were cooled in one box, a very bad arrangement. To make such a variety of residuums, reduced oils, etc., in three stills required constant changing and cleaning with an enormous loss of time, and the omnipresent difficulty occasioned by soiling the product of one distillation by that of the previous distillation. It was also impossible to so perfectly clean the stills, agitators, tanks and tank cars that the second charge was entirely free from the previous charge, yet some very good oils were made. The engineers of the locomotives of the Southern Pacific Railroad frequently filled their cans with our oil, declaring it was very much better than that which was provided them from some eastern refinery, and the Superintendent of Motive Power admitted the superior quality of our oils, but declared his inability to use them, as he was not the purchasing agent.

The gasolene and naphthas, while possessing a very different odor from articles of the same name and density made from eastern petroleum, were not found to be practically different when applied to the same uses. No burning oil was made. One batch was turned out without regard to cost as an experiment. In this instance the crude distillate was carefully washed with dilute sulphuric acid to remove basic oils. It was

then carefully treated with oil of vitriol and caustic soda and finished by distillation. It was beautifully colorless and brilliant, like the oils I had made thirty years before. Some of the best illuminating oil made from eastern petroleum in the Los Angeles market was obtained, and the two oils were filled into two new lamps with carefully-trimmed wicks. They were made as nearly alike as possible, and the combustion was made as nearly as could be identical. The eastern oil burned to the last drop and left the lamp dry. The California oil burned well for a time, then the flame became yellow, the wick crusted, and at last the flame was extinguished with the oil only about half burned. It was sought in the above-described experiment to make as good an oil as could be made from California crude oil without regard to cost. The result of the experiment was conclusive so far as Santa Paula oil was concerned; it afforded no encouragement whatever for the manufacture of illuminating oils from California crude, and confirmed the opinion that I had ventured years before and expressed, as above quoted.

I have in my possession a sample of the burning oil that I made from pressure distillate in 1867. It has become bright yellow in color, and a sediment of a deep orange color has gathered in the bottom of the bottle. The cork has been bleached for a long time, but the odor and density are unchanged. The change of color went forward when, for a number of years, the bottle was packed in a box excluded from light. In his report upon petroleum to the United States Census of 1890 the late Joseph D. Weeks stated that some of the wells near Newhall, Los Angeles County, furnished an oil that contained the paraffine series of hydrocarbons. Perhaps this opinion was based upon a report made by an unnamed chemist, whose results I was shown while in California, and who claimed to have isolated Warren's paraffine and isoparaffine groups, olefines and benzoles from the oils obtained by the Pacific Coast Company. I have myself obtained from these oils the esters of the nitrogenous basic oils, but the accidental loss of my specimen prevented me from investigating it further.

Soon after I reached California, in 1893, Dr. Salathé showed

me what he claimed was crude paraffine from one of the wells in the Torrey cañon. He dissolved some of the material in naphtha, filtered the solution, and, evaporating the naphtha, obtained a white, wax-like solid. He claimed that this experiment proved the existence of paraffine in the Torrey cañon crude oil. I afterwards visited the Torrey cañon and was given a mass of a dark-brown, wax-like substance, which I was told was the other half of the mass given Dr. Salathé, and that the whole was taken from the sucker rods of one of the wells. I have since examined this material sufficiently to prove that it does not consist of any form of paraffine, but is an unsaturated hydrocarbon, readily combining with sulphuric and nitric acids. It is no doubt a solid olefine or naphthene.

A great variety of lubricating oils were made of various densities. As already stated, a reduced green oil was prepared and sold under the name of "skid oil." All of the lubricating oils prepared from green crude oil were superior to those obtained from brown oil, they in turn being superior to those obtained from black oil. The causes of these differences I have not been able to fully demonstrate, but am convinced that they are found in radical differences in the crude oils. The crude black oils, without regard to density, appear to undergo more rapid decomposition than the green or brown oils, and the crude heavy distillates from black oils also appear to be less stable. Immediately upon the discovery of the presence of the basic oils I urged Dr. Salathé to remove them from the distillates and see what the effect would be upon the finished product. Accordingly, we washed 100 barrels of light lubricating distillate with 100 pounds of oil of vitriol, made into a 10 per cent. solution. The result was the complete saturation of the acid, the solution becoming brown, and tasting bitter instead of sour. The solution acquired a strong odor of a cow stable, indicating the presence of hippuric acid, which is a benzole product. On drawing off this solution it was followed by a tarry mass, nearly solid, very adhesive, and possessing great tenacity. A second treatment with dilute acid gave a solution that was strongly acid. After thorough washing with water, the oil was treated with the ordinary 5 per cent. of oil of vitriol,

which was accompanied with a copious disengagement of sulphurous oxide gas and a quantity of "sludge acid" having the usual appearance. The oil was finally treated with air-slacked lime, and finished in the settling tanks. Some of the heaviest lubricating distillates were finished in the still as reduced oils, and others were diluted with naphtha and treated, furnishing highly-finished products of fine quality. On pushing our applications for patents through the Patent Office, we found we were using processes already in use in the Scotch paraffine oil industry, although we were not aware of the similarity existing between both the materials and methods.*

A number of barrels of the acid solution of the basic oils were introduced into an agitator, an equal quantity of naphtha added, and the acid neutralized with a strong solution of caustic soda. As the naphtha was steam distilled, we supposed we could separate it from the basic oil by steam, but in this we were in error. The oils held about one-third of their bulk of naphtha when treated in a still with a steam coil through which steam was held at a pressure of 100 pounds. The mixed solution of three parts of oil and one part naphtha was put into a still heated directly and distilled to coke. The first naphtha that came over contained pyridin, but the amount of basic oils continued to increase until the sixth 5 per cent. was free from naphtha. These basic oils were all very heavy. They were at first of a brown color, then they became cherry red, and then brown again. The last that came over were heavier than water, through which they sank in drops like shot. A portion of the cherry-red oil of the proper density was found by Dr. Salathé to be nearly pure chinolin, which yielded some very fine purples and violets on silk. These oils readily dissolved in acid; the coke also was partially soluble in hydrochloric acid. From these acid solutions the hydrates of the basic oils were precipitated by caustic soda in cream-colored flakes. When these flakes were gathered on a filter they soon turned brown, and in time they completely evaporated at the ordinary temperature of the atmosphere.

The acid tar was soluble in alkaline solutions, from which

* S. F. Peckham, *Am. Jour. Sci.*, iii, **48**, 250.

it was again precipitated as a brown powder. The acid tar from green oil was of a brown color rather than black, and was also more nearly fluid than that from black oil.

All of these facts, which have been accumulated through many years, confirm the prediction that I made in 1871, which I have quoted above. It was also confirmed by the results of a fractional separation that I made a year ago, which results are stated in a paper which was read February 5, 1897, before the American Philosophical Society. This prediction is also confirmed by the results detailed by Professor Mabery, as he shows that the constituents of California petroleum are not to any appreciable amount paraffines, but belong to series having the formula $C_nH_{2n}$. I am convinced from the results of my own fractionation that a proportionately very large amount of benzole and its homologues are present, which fact accounts for the difficulty which has been experienced in all the attempts that have been made to prepare illuminating oils of good quality from California crude petroleum.

The polymerization of these oils, and the rapid conversion of both oils and tars into maltha and asphaltum, is, no doubt, due more largely to the presence of the unstable nitrogen and sulphur compounds than to the presence of any series of pure hydrocarbons. To what extent it is advisable to remove these compounds of nitrogen and sulphur from commercial products is, of course, a commercial as well as a technological problem. So, too, is the question as to how far these oils can be profitably made a source of pyridin and other benzole compounds.

# ELECTRICAL SECTION.

*Stated Meeting, January 11, 1898.*

## THE OVERHEAD LINE AND GROUND RETURN CIRCUIT OF ELECTRIC STREET RAILWAYS.

BY DAVID PEPPER, JR.
Member of the Institute.

On the proper design and careful construction of the line and ground return circuit depends, to a great extent, the satisfactory and economical operation of an electric railway. The practice of the present time is the result of costly experience. Within the last few years there have been great advances made in the character of the outside work, and the materials entering into the construction have been greatly improved. In the early days of electric street railways, the importance of the line, and especially the return circuit, was very little thought of. The cheapest form of construction that would cause the cars to move at all was usually installed. Managers now find that it is very bad economy to attempt to save money on their outside work. The direct loss in receipts and prestige, owing to failure of the outside construction, is very great; and the loss in power, owing to poorly proportioned or poorly constructed work, is a constant loss. The overhead trolley line should have sufficient strength in all its parts not only to hold up the dead weight of the trolley wire, but to resist all sudden and heavy strains caused by blows from trolley poles, the falling of outside wires upon the trolley wire, and the breaking of the trolley wire.

The trolley wire in city work is usually supported on iron poles placed, about 125 feet apart, in pairs on opposite sides of the street. These poles are usually made of from two to three sections of heavy iron pipe, telescoped into each other about 18 inches, and the joints swedged while hot. On straight line construction, unless the street is very wide, poles 28 feet long and weighing from 700 to 750 pounds are used.

On wide streets and light curves, and with extra heavy trolley wire, poles from 900 to 1,100 pounds are used. On heavy curves the poles weigh 1,300 pounds and over. In setting these poles, great care must be taken that they are set in such a way that there is no give at the base of the poles. If the poles give after the strain is put on them, it will loosen up the entire line, especially at curves and special work, and cause a great deal of trouble in repairing. The lighter weight poles, when set in fairly good ground and with a curbstone in front, should be placed in holes from 18 to 20 inches in diameter, and from 6 to 6½ feet deep, and set with a rake to allow for straightening when strain is placed on them. The concrete used should be made of 1½ bags of improved natural cement, one barrel of sand and sufficient stone to fill the hole. The sand and cement should be made into a thin mortar, mixed with the wetted stone, turned at least three times, and the mixture then rammed in the hole in six-inch layers. The concrete will be worthless if it is not properly rammed, or if there is too much or too little water in it. For pull-off poles, and where there are heavy strains, two bags of cement should be used and the poles set in larger and deeper holes.

In cross suspension work, the span wires are usually secured to poles with wrought iron bands, and one or two mechanical insulators are placed in each end of span, near pole. In the early construction, silicon bronze and solid steel and iron wires were used for the spans. It was found that the tensile strength of these wires, if they were scratched or kinked in any way, was greatly reduced, and that their composition was somewhat uncertain. Seven-strand galvanized steel cable is now used, $\frac{5}{16}$ of an inch in diameter for ordinary single-track suspension and pull-offs, and $\frac{7}{16}$ of an inch on long spans and $\frac{4}{0}$ trolley construction.

Care should be taken in placing spans to allow for the proper sag when the suspension device is sprung on the span wire. If the span is tight, say having a sag of only 8 inches in 35 or 40 feet, there is great strain put on the pole. If the sag is too great, the line will look bad and violent vibrations will be set up in it every time a car passes. The

exact tension of the spans is a matter of skill on the part of the man putting them up.

The insulators used in the span wire are of many types and makes. The insulation is usually hard-rubber compound or one of the many special compounds made for this purpose. There is a heavy strain sometimes placed on these span wires, and the constant vibration will quickly find any imperfections in the insulating material and cause either a break in the wire or a leak to the pole. Those forms of insulators involving screw connections are not usually as strong as those of rigid type; and, as the take-up is seldom if ever used in practice, it is better economy to use two solid strain insulators instead of a turnbuckle.

In many cases where the track is on the side of the street, a single line of poles is used and the trolley wire suspended from a pipe bracket, which is usually trussed in some manner. A plain bracket gives a rigid line, which causes a great deal of wear and tear. To overcome this rigidity, brackets are often made so as to rise a little under the pressure of the trolley, or the hanger is secured to a span wire under the bracket. Bracket construction, unless securely guyed, is much more liable to serious damage than span construction, owing to the lack of strength latteraly, if the wire breaks or if the trolley pole comes off and strikes the bracket.

We now come to the method of actually suspending the trolley wire. There is sprung on the span wire a casting of malleable iron or bronze, containing an insulated bolt of from $\frac{5}{8}$ to $\frac{3}{4}$ of an inch in diameter. This insulated bolt is sometimes placed in the casting and the top screwed down. In others it is contained in the body of the insulating material within the bell. The latter form is probably the best, owing to the much better protection given the insulating material from blows from the trolley wheel and from the weather. The principal advantage claimed for the other form of insulated bolt is that only one portion has to be thrown away in case of failure to work properly.

At curves, the trolley wire is suspended by special pull-off hangers placed sufficiently close to prevent sharp bends

in the trolley wire. The usual distance is from 6 to 10 feet, depending, of course, upon the degree of curvature. Where pull-off wires cross the straight line trolley wire, they should be secured to it the same as at the spans. The pull-off wires should all come together in an extra heavy strain insulator at the pull-off pole. It is well at this point to have a turn-buckle capable of tightening the entire series of pull-offs. Care should be taken in all pull-offs and special work to have each and every pull-off wire insulated from its neighbor, in such a way that in case of a failure of the pull-off insulation from the trolley to the pull-off wire, only one wire will be alive. When this precaution is not taken, it causes a great deal of trouble in locating the leak in a complicated curve.

In iron pole construction, the insulation is an important item, first, to prevent leakage to the trolley pole, which not only causes a steady loss but, perhaps, the shutting down of the lines, and also as a matter of safety to the men working on the live trolley wire. It is very disconcerting to a lineman working on a ladder or tower wagon to unexpectedly discover that the span wire, which he thought was insulated, is connected directly to the ground through the pole.

Probably one of the most important matters in trolley construction is the method of suspending the trolley wire from the hangers, and this is especially true on roads where the cars run at a speed exceeding ten miles an hour. The slightest obstruction on the underside of the trolley wire will cause the trolley wheel to leave the wire a short distance to come back again with a sharp blow. Each time the wheel leaves the wire there is an arc formed that takes off a small portion of the wheel or wire. If the obstruction is sufficient, the wheel will be thrown so far down from the wire that on its return it will miss the wire and go down the line striking span wires and special work, and straining every part of the overhead construction. This is one of the principal causes of trouble on the line. Probably one of the most satisfactory methods of suspending the wire is by using a bronze or composition ear, 15 inches long, with a groove of the diameter of the wire, milled in the solid of the

lower portion of the ear, the depth of this groove to be about the diameter of the wire. The extra portion of the metal is so proportioned that it can be securely hammered down on the trolley wire. The ear should then be carefully soldered, using soldering salts and solder; this, when properly done, makes a first-class job, but there is danger that the wire may be damaged by careless or unskilled workmen. Should the iron be so hot as to partially anneal the trolley wire, there is a very great reduction in tensile strength at the ear, and the wire may be so damaged that on the first strain it will draw out and break. Only the most skilful men should be entrusted with this work, as it requires care and skill that can only be obtained by practice.

To give a smooth under-running surface to the trolley wire, many devices have been tried. The trolley wire has been rolled in the form of the figure 8, and a mechanical clamp devised to hold the wire in place, giving, theoretically, a smooth under-running surface. Unfortunately the wire, in practice, is likely to be twisted slightly in the erection and at curves, with the result that the trolley wheel runs on the two loops of the wire, giving extremely unsatisfactory results. To overcome this trouble, the section of wire was modified to three points, instead of two, and this has been found to work much better. Another plan, of good promise for high speed work, was to take a four naught round trolley wire and with a special machine to press or mill a groove on each side of the wire, just above the diameter, to fit a clamp. This device answers very well, but it is somewhat difficult to repair work put up in this manner. Another class of suspension involves the use of metal below the trolley wire. Others involve the kinking of the trolley wire. Both of these last-named methods are open to serious objections for high-speed roads.

Another important part in the work is the joining of the trolley wire. This can probably be best accomplished by a long, hard-rolled copper sleeve, about 18 inches long, turned to a cone at each end and so arranged by boring and milling groves that the wires come out together in the middle

of the sleeve. The hole is then soldered and the surplus wire cut off. Another style, without solder, involves some form of clamping device within the tube, the inner chamber being larger than the bore for the trolley wire to enter.

In all special work, such as frogs, cross-overs and section breaks, care should be taken to choose that which gives a clear under-running surface. In high-speed work the tendency is to entirely avoid switches and to substitute for same two trolley wires, or cause the trolley to be lowered and placed on another wire on cars leaving the main line. At any speed above ten miles an hour, the chances are greatly in favor of the trolley wheel leaving the wire.

In the early days No. 6 to No. 4 B. & S. gauge wire was considered quite heavy enough for the trolley wire. It was soon discovered, however, that this was entirely too light, and for many years single naught hard-drawn copper wire was used. The tendency is strongly in favor, for standard city work, of the use of double naught wire. It has been proved by experience that the troubles from the breaking of the trolley wires are reduced to about one-third the number when double naught wire is used. If single naught trolley wire is drawn so tightly that the up and down vibrations only show for three or four poles, the wire is strained well up towards its safety limit, and will not stand a sudden and violent blow. The wire should be stretched so that in winter there will be a sag of about 10 inches in every 125 feet. This will make a considerably looser line in summer time.

In deciding upon the size of trolley wire, there are several other problems to be considered besides the tensile strength and freedom from accidents. In a net work of wires such as here in Philadelphia, the trolley wire is not usually depended upon as part of the feeder system, other than for six or eight cars on a single section. In suburban lines, with comparatively few cars, the question of using the trolley wire as part of the feeder system becomes an important one; and the difference between one naught and two naught trolley, and still more so between two naught and four naught trolley, will determine whether or not a heavy feeder will have to be run alongside of the trolley

wire. The cost of bare copper in the form of two naught or four naught trolley is considerably less per circular mil than the cost of a single naught trolley wire plus the necessary insulated feeder wire.

In designing any feeder system, the proposed conditions upon which the line is to be run should be very well known, and the line designed for economy of current and original investment for average load, with the provision made that on very heavy loads the voltage will not fall below 375 volts for a few moments. One of the causes of the failure of insulation on iron-pole construction is the effect of lightning discharges on the line, which greatly weaken and strain the insulators, even if they do not break down on the first discharge. To overcome this, it is usual to place one of the well-known and tried makes of lightning arrester at each feeder tap, providing it with a kicking coil, and being careful that there be as few bends as possible in the wire to the ground. The lightning arrester should preferably have a single naught tinned wire run down inside of the pole and connected securely to the return circuit and track. The mere grounding of a lightning arrester to a trolley pole set in concrete is not sufficient, as, even on a wet day, there have been cases known where the concrete acted as such a good insulator that there was a difference of potential of 475 volts from pole to track. On wooden-pole construction, the problem of insulating is very much simplified, as eighteen or twenty feet of wooden pole, properly painted, is probably as good an insulator as can be made. Wooden poles of sufficient weight and of first-class yellow pine, chestnut, oak or cedar, painted with a preservative compound at the butt and painted two coats of good paint, are as satisfactory as iron poles; and, in the long run, as well as in first cost, are a little cheaper. They will last about one-third as long as the estimated life of an average iron pole properly painted.

The limitations to the overhead trolley are now quite generally recognized. It has been found that it is difficult to efficiently transmit, by means of the ordinary form of trolley wheel, more than 150 amperes from the wire to the wheel without excessive sparking and loss. The speed at

which a trolley wheel will stay on the wire, through section insulators, special work and switches, is limited in good practice to not much over ten miles an hour. When the trolley stand and wheel are both designed for high speed and the line carefully constructed, it is possible to run on straight-line work at a speed of about thirty miles an hour. Beyond this speed the tendency to throw the wheel from the wire, owing to slight obstructions on the trolley wire, is very great. If the wheel leaves the wire at this speed, it is almost certain to either break the trolley pole or bring down a large portion of the overhead construction. It is for this reason that experiments have been and are being tried to substitute a fixed conductor near the ground with a large surface contact for the overhead trolley wire, for high speed and heavy currents.

A great deal of attention has recently been given to the matter of ground return. It has been found that the current on an imperfectly bonded track is very likely to come back to the station through water and gas pipes and on the lead covering of underground cables, setting up electrolitic action, which, in some instances, speedily destroyed the pipes. In bonding a track, the first thing to be considered is to get as low a resistance as possible at each joint. It is also necessary to have an assurance that the bond will remain in perfect condition for a long period of time and will stand the maximum current that will be called upon to go through a special piece of track. The actual cost of the material for bonding a track, with most modern systems of bonding, is a small item compared to the original labor of putting it in place and the cost of re-bonding the track within a few years, without taking into consideration the watts daily lost in the bond circuit. Few persons realize how low a resistance a pair of nine-inch girder rails have, and that every effort should be made to get the full benefit of this return circuit. The resistance of the rail is from six to seven times the resistance of the same section of commercial copper. Very few tracks are bonded more than one-fourth or one-third the carrying capacity of the rail. It has been proved in practice that the earth and fish plates are not to be depended on as part of the return circuit for heavy currents.

# THE CHEMISTRY OF HIGH TEMPERATURES.

[*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the investigations of M. Henri Moissan, with the electric furnace.*]

[No. 1,953.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 1, 1897.

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of Moissan's investigations with the electric furnace, reports as follows:

The researches conducted by M. Henri Moissan, with the aid of his electrical furnaces, extend over a period of about five years, and have won for this distinguished chemist an additional title to take rank with the foremost exponents of scientific inquiry at the close of this century of science, so auspiciously inaugurated by the great discoveries of Gay Lussac and Sir Humphry Davy.

In preparing a report upon the work of the French chemist, your committee feels that it might well be content to pass in review those brilliant discoveries which have become universally known, and that it would scarcely be possible to refer to all the valuable and interesting results without making the report too voluminous.

At the same time, the committee believes that much of M. Moissan's purely scientific work has not been as generally recognized as it deserves to be, and, therefore, begs to present the following statement:

The application of the high temperatures attainable by means of the electric arc, for the purpose of producing physical and chemical effects, is by no means of recent date. Many important observations on the effects of electric heat were made already by Van Marum, at the close of the last century, and by Humphry Davy, the discoverer of the arc, at the beginning of the present one. In 1849 Despretz utilized the intense heat of the arc in various scientific investigations, and later

Pichon, Siemens and Huntingdon, Cowles, Heroult, Grabau, Borchers, Acheson, Willson and many others either suggested or realized the employment of the electric furnace for various industrial purposes.

In all these cases, however, the materials subjected to the arc were directly exposed to and permeated by it. But, while this may not be objectionable in many industrial processes, the presence in the arc of vapors of carbon and other substances emanating from the electrodes, and the attendant electrolytic action, constitute a set of disturbing influences which will generally complicate the results, and render them liable to lead to erroneous conclusions.

Guided by these considerations, M. Moissan endeavored to devise a furnace which would subject bodies to the highest temperatures of the electric arc under simple and controllable conditions. He has constructed five modifications of such a furnace, which are characterized by the following features:

(1) A furnace consisting of a block of lime, hollowed out, and provided with electrodes in such a manner as to maintain the arc above the substance. The cavity is lined with suitable materials.

(2) A furnace of fine-grained limestone lined with alternate layers of carbon and magnesia, the former on the inside. This construction permits the use of higher temperatures than the preceding one, and is well adapted for receiving crucibles.

(3) A furnace provided with a tube of refractory material, passing horizontally through the cavity. This arrangement affords a heated space, which is accessible from without, and protected from the action of any gases existing within the furnace. When desired, currents of gases or vapors can be passed through the tube while it is being heated.

(4) A furnace in which the tube is given an inclined position, which permits a continuous operation; the charge is introduced at the upper mouth, while the products are removed or flow from the lower one.

This model was employed for preparing large quantities of pure products in a short time.

(5) A furnace with a larger number of electrodes and arcs.

By this means a considerable space can be evenly heated, and large amounts of material treated in one operation.

By thus excluding electrolytic action, M. Moissan was enabled to investigate the simple heating effect of the current. The temperature ranged from 2,000° to beyond 3,800° C. While it is not possible to give exact figures for the highest temperature attained, an idea of the conditions may be formed from the description of some of the experiments. The currents employed varied from 35 ampères at 55 volts to about 1,600 ampères at 110 volts.

The results obtained by means of the electric furnace may be considered comprehensively under the following heads:

I. *A series of researches on the fusion and volatilization of refractory bodies.*

Various compounds and elements which are either infusible or non-volatile at the highest temperatures attainable by combustion were melted or vaporized when subjected in the furnace, Model 1, to an arc consuming 30 to 40 horse-power of energy.

Thus lime, magnesia, molybdenum, tungsten, vanadium and zirconium were readily fused, and lime, silica, copper, platinum, aluminium, boron, carbon and other refractory bodies volatilized.

Many of these bodies were obtained, either by fusion or sublimation, in a crystallized form.

By heating mixtures of several oxides a series of new double oxides was prepared.

II. *In a second series of experiments a number of reactions, which can be effected at the highest temperatures only, were made the subject of investigation.*

The carbonates of barium and strontium were without difficulty resolved into carbonic acid and the oxides. Those oxides which had withstood the de-oxidizing action of carbon at the highest temperature of ordinary furnaces were readily reduced by that element in the electric furnace; others, whose reduction by carbon in the wind furnace is difficult or incomplete, readily yielded their oxygen to the carbon under the action of the arc.

It was thus possible to obtain aluminium, silicon, the alkaline-earth metals, uranium, vanadium and zirconium. Moreover, manganese, chromium, tungsten and molybdenum were produced in the reguline state and in considerable quantities. Certain ingenious precautions were observed to prevent the metals named from combining with oxygen, nitrogen and carbon, and to remove the last-named element after a carbide had been formed.

As many of these products were for the first time obtained in the pure state or in much larger quantities than before, a careful study of their properties afforded innumerable new and interesting observations, and led to the revision of many statements published by former investigators.

The study of chromium and vanadium proved especially interesting. Titanium was found to be converted into the nitride when subjected to an arc produced by a current of 400 ampères and 60 volts, but to remain metallic when a current of 1,200 ampères and 70 volts was employed.

Reductions were also effected by substituting metallic reducing agents for the carbon, and interesting new alloys were thus prepared.

III. *The study of the three allotropic modifications of carbon constituted a third extended series of experiments.*

It is impossible here to do more than mention a few of the more important results.

The most important, perhaps, and the one which has become universally known, is that ordinary charcoal may, by means of the electrical furnace, be converted into diamond.

When molten iron at 3,500° is saturated with carbon and the mass then suddenly chilled on the outside, the enormous pressure produced in the interior will cause part of the carbon which separates to crystallize in the form of diamond. Both the transparent and the black (carbonado) varieties were thus obtained—the former in octahedra and cubes, as well as in fragments; the specific gravity of 3·5, the hardness and all characteristics corresponded to those of the native stone.

It is further shown that, at about 3,000°, under ordinary pressure, all the modifications of carbon are converted into

graphite, and various varieties of this (the ultimately stable form of carbon) were recognized and studied.

The reason for the infusibility of carbon under ordinary pressures was established to be due to the fact that it passes directly from the solid into the gaseous condition. Carbon was actually sublimed and the reactions of its vapor studied.

IV. *There yet remains to consider the investigation of several new series of crystallized compounds belonging to the classes of borides, silicides and carbides.*

M. Moissan has shown that these compounds, as a rule, have very simple compositions, and that, at the highest attainable temperatures, carbon, silicon, and boron generally form but one compound with another element.

The silicides, like Acheson's carborundum, possess extraordinary hardness; some, as those of boron and titanium, appear to be even harder than the diamond.

Of the metals, some do not combine with carbon; others while dissolving it at very high temperatures deposit it as graphite before they solidify. A very large number of metals, however, form definite, crystallized carbides.

These M. Moissan divides in two classes; those which decompose water at ordinary temperatures, as, for example, the carbides of the metals of the alkalies and alkaline earths, of aluminium, cerium, etc.; and those which do not react in this manner, and which include the carbides of chromium and titanium.

It appears that M. Moissan was the first to produce the crystallized calcium carbide in the electric furnace. He has also exhaustively studied the action of the various carbides on water. In a few cases, as with calcium carbide, there resulted a single hydrocarbon in a pure state; in others, mixtures of hydrogen with one or several hydrocarbons, such as methane, ethylene and acetylene. The most interesting carbides in this respect, however, are those of cerium and uranium. They were found to yield not only gaseous hydrocarbons but considerable quantities of liquid and solid hydrocarbons.

M. Moissan believes that analogous reactions play an important role in the formation of natural gas, petroleum and

other natural hydrocarbons; he has advanced a new and interesting theory in regard to this.

The above is but a meager resumé of the work done by M. Moissan with his electric furnace. The enormous number of new and valuable results obtained by him necessitated a selection. In studying the effects of extreme temperatures the French chemist has opened up a new and extended field to scientific research, and the harvest already reaped from it has greatly enriched our stores of knowledge in the provinces of chemistry, physics and geology. Innumerable practical applications suggest themselves, and not a few have already been realized.

As a conclusion, we wish further to state that the manner in which he has described, interpreted and summarized his experiments and his results cannot fail to incite others to follow the paths he has prepared, and lead them to further discoveries in this field.

In view of these facts, your committee takes pleasure in stating that the highest award the Franklin Institute can bestow could not find a worthier recipient than the author of these researches.

The Franklin Institute, therefore, awards the Elliott Cresson Medal to M. Henri Moissan, of Paris, France, for his work on the chemistry of high temperatures.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, December 1, 1897.

JOHN BIRKINBINE, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by

JAMES CHRISTIE,
*Chairman of the*
*Committee on Science and the Arts.*

# On the MOLECULAR CHANGES in CAST IRON CAUSED by VIBRATION.

[*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the investigations of Mr. A. E. Outerbridge, Jr.*)

HALL OF THE FRANKLIN INSTITUTE,
[No. 1,910.] PHILADELPHIA, May 5, 1897.

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of Outerbridge's Investigations in the Molecular Physics of Cast Iron, reports as follows:

The work of Mr. Outerbridge, under consideration, has been so often and so fully described in the technical press, and in the papers herewith submitted by him, that an extended notice is unnecessary. In brief, certain deviations from the expected strength of test bars, made in connection with his work, led Mr. Outerbridge to make an investigation as to their previous treatment, and it was found that the only assignable cause for the increased strength noted was the fact that they had been, contrary to the usual custom, rumbled in a mill in order to clean them. Mr. Outerbridge followed up this observation with a careful and scientific investigation regarding the effect of vibration on cast iron, confined, however, to a limited range in the composition of the samples.

Many of his earlier results are given in the papers submitted by him. It is to be regretted that the later results, as well as some of the practical applications, cannot be laid before the Institute, as showing more clearly the decided value of Mr. Outerbridge's work. The principal result has been to largely upset some of the ideas generally held on the subject of cast iron, and where formerly it was considered essential that small or light castings must be protected from shock, it is now believed that they may be generally strengthened and relieved of their internal cooling strains by judicious treatment in this way.

Members of the sub-committee have made many experiments similar to Mr. Outerbridge's, for transverse strength, and they believe that where the proper conditions are observed there will be a decided gain in strength in almost every case, at times running as high as 35 or 40 per cent. increase in the rumbled over the unrumbled bar (some of these results are appended hereto). Many others have made similar experiments with the same results, both with high and low silicon irons.*

The fact that a certain molecular change takes place in cast iron in the course of time has been known and recognized by many persons for a long time, and that this change tends to relieve the internal strains and render the casting tougher has often been noticed and acted on, although in a very crude way; but, so far as this body has been able to learn, Mr. Outerbridge has been the first one to make a careful study of this subject and to note that the change may be hastened by impact, and the whole effect produced in a short time, and also to make a scientific study of the phenomenon. We believe great credit is due to him for the initial observation and the careful work dependent thereon. The results were first given to the public in a paper read

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* Dr. H. I. Hannover, Professor of the Royal Technical High School and Director of the New Danish Government Testing Laboratory, at Copenhagen, published an article on A. E. Outerbridge, Jr.'s "Researches on Molecular Changes in Cast Iron," giving in full the report of the Committee of Science and the Arts of the Franklin Institute, together with the table of tests made by the committee in the course of the investigation. In this table there appeared some clerical errors, which did not, however, affect the correctness of the conclusions.

Professor Hannover first discovered these errors, and alluded to them in a foot-note to his article, which appeared in the journal *Baumaterialienkunde* Nos. 11 and 12, page 181, July, 1897 to 1898.

In *Stahl und Eisen* (March 1, 1898), Prof. A. Ledebur gives the substance of Professor Hannover's paper. and shows by averaging the errors that they do not materially alter the result. He calls attention to an increase in strength of iron bars, due to mechanical treatment, noted in his "Handbook of Iron and Steel Melting." He says (p. 62) "I have given as the mean bending strength of cast iron—

| | | |
|---|---|---|
| Unworked . . . . . | 25 kilograms | } 1 sq. mm." |
| Worked . . . . . | 29 " | |

W.

TESTS MADE BY SUB-COM. No. 1910, ON BARS 26 x 2 x 1—TESTED FLAT, 24 INCHES BETWEEN SUPPORTS.

| | | Not Rumbled. | | Rumbled. | | Per Cent. Increase. | | | | Not Rumbled. | | Rumbled. | | Per Cent. Increase. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date. | No. | Load. | Defl. | Load. | Defl. | Load. | Defl. | Date. | No. | Load. | Defl. | Load. | Defl. | Load. | Defl. |
| 1-22 | A-1 | 2100 | 33 | 2510 | 44 | 19 | 33 | 2-1 | A-44 | 2340 | 37 | *2530 | *43 | 8 | 16 |
| | 2 | 1820 | 29 | 2280 | 39 | 25 | 34 | | 45 | 1830 | 29 | 2575 | 40 | 40 | 37 |
| | 3 | 2336 | 38 | 2830 | 48 | 21 | 26 | | J-1 | 2355 | 40 | 2480 | 49 | 5 | 22 |
| | 4 | 2175 | 32 | 2510 | 45 | 15 | 40 | 2-2 | A-46 | 2125 | 31 | 2925 | 44 | 37 | 41 |
| | 5 | 2122 | 35 | 2430 | 47 | 14 | 34 | | 47 | 2100 | 34 | 2170 | 36 | 3 | 5 |
| 1-23 | 6 | *1725 | *32 | *2000 | *39 | 15 | 21 | | 48 | 2000 | 31 | 2600 | 44 | 30 | 41 |
| | 7 | 2268 | 35 | 2360 | 41 | 4 | 17 | | 49 | 1980 | 31 | 2100 | 32 | 6 | 3 |
| | 8 | 2000 | 31 | 2640 | 42 | 32 | 34 | | 50 | 1975 | 31 | 2630 | 43 | 33 | 38 |
| | 9 | 2358 | 35 | 2675 | 42 | 13 | 20 | | J-1 | 2100 | 43 | 2470 | 51 | 17 | 18 |
| | 10 | 2114 | 33 | 2215 | 40 | 4 | 21 | 2-3 | A-51 | 2132 | 35 | 2565 | 43 | 20 | 22 |
| 1-25 | 11 | 1930 | 30 | *2130 | *38 | 10 | 26 | | 52 | 2116 | 32 | 2550 | 44 | 20 | 37 |
| | 12 | 2362 | 32 | 2500 | 35 | 5 | 9 | | 53 | 1950 | 30 | 2175 | 34 | 11 | 13 |
| | 13 | | | | | | | | 54 | *1867 | *28 | 2250 | 35 | 20 | 25 |
| | 14 | 2265 | 31 | *2945 | *40 | 30 | 29 | | 55 | 2055 | 34 | 2435 | 50 | 18 | 47 |
| | 15 | 2062 | 36 | 2680 | 39 | 29 | 8 | | J-1 | 2211 | 40 | 2500 | 46 | 13 | 15 |
| 1-26 | 16 | 1968 | 32 | 2145 | 33 | 8 | 3 | 2-4 | A-56 | 1925 | 33 | 2375 | 44 | 23 | 33 |
| | 17 | 2200 | 35 | 2630 | 44 | 19 | 25 | | 57 | 2120 | 37 | 2110 | 36 | **0.4†** | **2** |
| | 18 | 2175 | 35 | 2465 | 39 | 13 | 11 | | 58 | 1850 | 30 | 2320 | 39 | 25 | 30 |
| | 19 | 2106 | 32 | 2400 | 37 | 13 | 15 | | 59 | 2085 | 33 | 2000 | 29 | **4** | **12** |
| | 20 | *1618 | *28 | 2175 | 37 | 34 | 32 | | 60 | *2015 | *34 | 2490 | 44 | 23 | 29 |
| 1-27 | 21 | *1778 | *31 | 2275 | 37 | 27 | 19 | | J-1 | 2130 | 36 | 2525 | 40 | 18 | 11 |
| | 22 | 2175 | 32 | 2525 | 41 | 16 | 23 | 2-5 | A-61 | 2170 | 30 | 2505 | 38 | 15 | 26 |
| | 23 | 2265 | 36 | 2622 | 45 | 15 | 25 | | 62 | 2475 | 39 | 2820 | 49 | 13 | 25 |
| | 24 | 2192 | 31 | 2640 | 39 | 20 | 25 | | 63 | *1632 | *27 | 2320 | 40 | 42 | 48 |
| | 25 | 2180 | 34 | 2425 | 37 | 11 | 8 | | 64 | 2320 | 36 | *1860 | *30 | **19** | **16** |
| 1-28 | 26 | 2080 | 34 | 2360 | 42 | 13 | 23 | | 65 | *1860 | *31 | *1800 | *28 | **3** | **9** |
| | 27 | 1911 | 32 | 2255 | 39 | 18 | 21 | 2-6 | 66 | 1975 | 32 | *1865 | *32 | **5** | **0** |
| | 28 | 2205 | 36 | 2345 | 38 | 6 | 5 | | 67 | 2060 | 35 | 2365 | 36 | 14 | 2 |
| | 29 | 2197 | 35 | *2400 | *36 | 9 | 2 | | 68 | 1810 | 28 | 2520 | 41 | 39 | 46 |
| | 30 | *2185 | *35 | 2550 | 45 | 16 | 28 | | 69 | 2000 | 32 | 2425 | 38 | 21 | 18 |
| 1-29 | 31 | *1821 | *31 | 2130 | 37 | 16 | 19 | | 70 | 2000 | 35 | *1650 | *28 | **17** | **20** |
| | 32 | *1845 | *31 | *1990 | *32 | 7 | 3 | | J A | 2000 | 32 | 2640 | 42 | 32 | 31 |
| | 33 | *2135 | *28 | 2500 | 38 | 17 | 35 | 2-8 | A-71 | 1960 | 33 | 2235 | 41 | 14 | 24 |
| | 34 | *1900 | *30 | 2000 | 31 | 5 | 3 | | 72 | 2325 | 36 | *2290 | *38 | **1** | 5 |
| | 35 | 1970 | 30 | 2110 | 34 | 7 | 13 | | 73 | 2000 | 31 | 2595 | 44 | 29 | 41 |
| | J-2 | | | | | | | | 74 | 1935 | 30 | 2475 | 38 | 27 | 26 |
| 1-30 | A-36 | 1868 | 29 | 2210 | 40 | 18 | 37 | | 75 | 1925 | 32 | 2592 | 45 | 34 | 40 |
| | 37 | 1832 | 29 | 2310 | 37 | 26 | 27 | | J A | 2215 | 38 | 2120 | 44 | **4** | 15 |
| | 38 | 2000 | 29 | 2150 | 35 | 7 | 20 | 2-9 | A-77 | 2150 | 31 | 2490 | 43 | 15 | 38 |
| | 39 | 1955 | 30 | 1875 | 30 | **4** | 0 | | 78 | 2020 | 31 | 2515 | 43 | 24 | 38 |
| | 40 | 1940 | 29 | *1970 | *32 | 1 | 10 | | 79 | 2095 | 31 | 2235 | 35 | 6 | 12 |
| | J-1 | 2236 | 41 | 2600 | 48 | 16 | 17 | | N-80 | 2000 | 31 | 1920 | 33 | **4** | 6 |
| 2-1 | A-41 | 2175 | 33 | 2310 | 40 | 6 | 21 | | N-81 | 1920 | 27 | 2340 | 40 | 21 | 48 |
| | 42 | 1773 | 29 | 2360 | 45 | 33 | 55 | | S-82 | 2100 | 31 | 2305 | 34 | 9 | - |
| | 43 | 2233 | 37 | 2500 | 46 | 11 | 24 | | S-83 | 1940 | 35 | 2135 | 43 | 10 | 22 |

* Defective

†A Decrease is shown by bold-face figures.

before the American Institute of Mining Engineers, on February 20, 1896. This aroused a widespread interest and discussion among users of cast iron, and, so far as the subcommittee has been able to determine, it has not been shown that any one, either in this country or abroad, has antedated Mr. Outerbridge in his work in this line.

The Franklin Institute therefore recommends the award to him of the John Scott Legacy Premium and Medal.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, June 2, 1897.

JOHN BIRKINBINE, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by

JAMES CHRISTIE,
*Chairman Committee on Science and the Arts.*

[Award confirmed by the Directors of City Trusts.]

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## THE WILLIAMS TYPEWRITING MACHINE.

[*Being the report of the Franklin Institute, acting through its Committee on Science and the Arts, on the invention of John N. Williams.*]

[No. 1956.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 22, 1897.

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of the Williams Typewriting Machine, reports as follows:

This is a keyboard, type-bar, machine, with the type-bars divided into two groups, before and behind the platen, at the top of the machine (*Fig. 1*); the types striking the platen and printing on top. The movement of the type-bar is similar to that of the upper limb of a parallel ruler (*Fig. 2*) set on edge and carrying a type on the end of the upper limb, resting on an inked pad when in position as if the two limbs were together, and striking the platen when extended. Each type-bar (of which there are twenty-eight) carries

three letters or characters, as may be, and the platen has two shifts, bringing all of them (eighty-four) into action. The paper passes down on both sides of the platen and is rolled in cradles provided for it on both sides.

The printing is in full view of the operator, and being done directly from the type, has a sharpness not attainable with a ribbon.

The applicants claim for it the following points of superiority, which are discussed in their order.

(1) *Visible Writing.*—There are some other machines which write visibly; but there is no other which writes visibly direct from the type, giving, at the same time, the quality of work and the convenience of inspection.

FIG. 1.

(2) *Direct Inking.*—There is one other keyboard machine, and some single-hand machines, which ink direct from the type. The ink-pad is more easily and quickly re-inked or changed, for change of color, than on any other machine.

(3) *Speed.*—The machine has high speed, probably beyond that of any operator; but with most of the first-class machines the limit of speed is that of the operator, and not of the machine.

(4) *Alignment.*—The alignment is necessarily perfect, because the bearing is guided; but this feature is in some other machines.

(5) *Manifolding.*—The Williams Machine is an excellent manifolder. It has a certain liability, in heavy manifolding,

to take an impression from the edge of the upper-case letter, on the top sheet, which, however, by special care on the part of the operator, can be avoided.

(6) *Mimeographing.*—It cannot fail to make first-class stencils for mimeographic work.

(7) *Keyboard.*—The keyboard has the advantage and facilities of compactness and convenience over the keyboard on some other machines, having two shifts.

(8) *Carriage.*—The carriage is light-running and convenient.

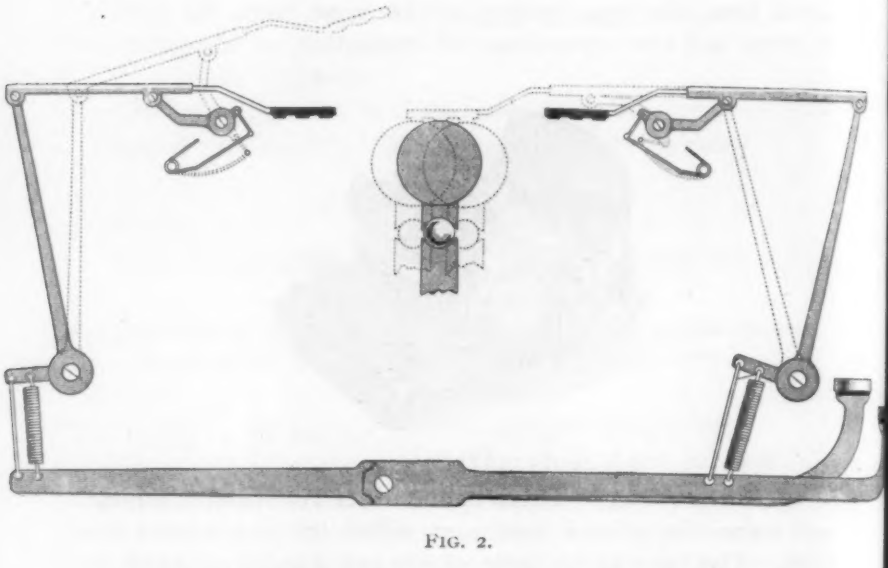

FIG. 2.

(9) *Carriage Lock.*—This is a device by which it can readily be fastened in place, for shipment.

(10) *Line Lock.*—This device locks the machine at the end of the line, and prevents the stroke of the type, with a further capability of two letters, disengagement for which is done by a touch on the key, enabling the use of these two letters where they are needed for completion of a word, which is a very convient feature.

(11) *Line Spacing.*—This machine has three adjustments for spacing, while most machines have two; but there are

several other machines by which a similar wide range of adjustment can be made, quite as conveniently as on this.

(12) *Marginal Stop.*—This is not dissimilar to that of other machines.

(13) *Interchangeable Platens.* — Platens on several of the machines are interchangeable.

(14) *Economy of Maintenance.* — There is considerable economy as compared with machines using ribbons, which is paralleled by the other machines using pads.

(15) *Type always Clean.*—This is correctly stated.

(16) *Tabulating.*—This machine can be used very advantageously for tabular work, due to the fact that the work is in plain view, and the platen can be put in any position required, regardless of its feed.

(17) *Quality of Work.*—There is no doubt that the work from a machine printing directly from the type is superior to that which prints through a ribbon; but this advantage is shared by other machines which print directly from the type.

(18) *Simplicity, Compactness and Durability.*—This machine is simple and compact, and all parts are in plain view and easily accessible. There appears to be no reason why it should not be quite satisfactorily durable.

The Williams' Machine has a light, free touch and positive movement of its platen escapement.

This machine is covered by, and described in, the following patents to John N. Williams, to wit: No. 523,028, dated July 17, 1894; No. 501,753, dated July 18, 1893; No. 442,697, dated December 16, 1890; and also a patent to James Brady, No. 431,869, dated July 8, 1890, which covers the escapement only; and, while this is a very material part of the machine, it is so simple that it is not necessary to take account of it in considering the general merits of the machine.

In view of these advantages, the Franklin Institute recommends the award of the John Scott Legacy Premium and Medal to John N. Williams for his improvements in typewriting machines.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, June 2, 1897.

JOHN BIRKINBINE, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by

JAMES CHRISTIE,
*Chairman of the*
*Committee on Science and the Arts.*

[Award confirmed by the Board of Directors of City Trusts.]

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## BOOK NOTICE.

*The Metallographist.* A quarterly publication devoted to the study of metals, with special reference to their physics and microstructure, their industrial treatments and applications. Edited by Albert Sauveur. Published by the Boston Testing Laboratories, 446 Tremont Street, Boston, Mass., U. S. A. [Price, $2 per annum.]

The great extension of our accurate knowledge of the metals and alloys emplóyed in the constructive and mechanical arts, that has resulted from the application of refined methods of physical investigation, has made it clear that many of the qualities upon which depend the value of those materials in the arts are determined very largely by the physical conditions attending their production and subsequent manipulation; and that without the full, knowledge of these physical data, chemical composition is apt to prove a most uncertain alliance. It is only necessary, in proof of this statement, to refer to a single fact, namely, the preponderating influence of the heat treatment of the metals upon their structure, the segregation of accessory constituentst etc., as revealed by the examination under the microscope; and many other confirmatory facts could be adduced.

The new magazine has an important and constantly widening field to call its own.

The editor is well and favorably known as an industrious and intelligent investigator of the micro structure of metals, and, if the contents of the first two numbers be taken as a specimen of those to follow, it gives promise of proving a substantial acquisition to current engineering literature. W.

# Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, June 15, 1898.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 15, 1898.

MR. JOHN BIRKINBINE, President, in the chair.

Present, 46 members and 2 visitors.

Additions to membership since last report, 9.

The Secretary reported the resignation of Prof. F. L. Garrison from the Committee on Science and the Arts. The vacancy was filled by the election of Mr. A. M. Greene, Jr.

Mr. Wilfred Lewis read a paper describing "An Inertia Indicator," which was illustrated with a specimen of the apparatus and blackboard explanations. This ingenious mechanical device was originally designed by the inventor for the purpose of determining the reaction of travelling cranes on their tramways, and is susceptible of application in many other situations. Referred to the Committee on Science and the Arts for investigation and report.

Mr. Edwin L. Decker, of Carlstadt, N. J., described and illustrated by means of a series of lantern slides the "Gas Composimeter," devised by Messrs. Uehling, Steinbart & Co., of Newark, N. J., for the automatic analysis of the flue gases discharged from steam boiler furnaces. The instrument makes a continuous record of the percentage of carbon dioxide in furnace flues, and is intended to be used as an indicator in boiler-rooms to serve as a controller in the economic service of boiler fires.

The Secretary presented his monthly report, which included an exhibition of a series of views of Philippine Islands, loaned for the purpose by Dr. Brooks, Superintendent of the Public Schools.

Adjourned.

WM. H. WAHL, *Secretary.*

## COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of the proceedings of the special meeting held Wednesday, June 22, 1898.*]

PROF. L. F. RONDINELLA in the Chair.

The following reports were adopted:

*Severy Impression Process.*—Melvin L. Severy, Boston, Mass.

ABSTRACT.—The purpose of this invention is to do away with the necessity of specially preparing the impression bed of a printing press to properly receive the impression of the form to be printed—in other words, to do away with the process known in the trade as the "make-ready."

To accomplish this result, the inventor makes use of an elastic wire fabric as the tympan or covering of the impression bed of the press, in place of the covering commonly in use. This fabric is formed of steel wire, and its surface presents a close array of these wires, resembling what is known in the textile arts as "card clothing." In printing, this fabric is covered with a thin sheet of hard rubber. The tympan thus formed seems to combine, in marked degree, the facility of a soft tympan with the qualities of a hard one.

A series of tests of the Severy tympan, made by the Committee on a quarto platen press, indicated that the Severy tympan afforded decided advantage over the ordinary impression tympan, rendering from a number of various forms, without special "make-ready," such excellent impressions as give full promise of valuable economic results.

The report concludes as follows: In conclusion, while the investigating committee feels constrained to withhold its unqualified acceptance of the very broad claims to usefulness made in behalf of this invention, pending the ascertainment of the results of its practical application in continuous use, it is, nevertheless, of the opinion that Severy Impression Process deserves recognition at the hands of the Institute as an invention both original and important. The award of the Scott Premium and Medal is recommended. The Severy Impression Process is protected by U. S. Letters-Patent No. 549.641, November 12, 1895. [*Sub-Committee.*—Louis E. Levy, Chairman; Hugo Bilgram, Wilfred Lewis, Edward Stern, George H. Buchanan, Frank E. Manning, Wm. H. Greene, Samuel Sartain.]

*Improvements in Roentgen Ray Tubes.*—H. Lyman Sayen, Philadelphia.

ABSTRACT.—The object of this invention is to increase the life, range of usefulness and efficiency of X-Ray tubes by providing them with automatic means of obtaining and maintaining the desired vacuum for the work to be done. It is protected by U. S. Letters Patent No. 594,036, November 23, 1897.

The invention under consideration, and as described in the letters-patent above referred to, aims at the provision of special means for the automatic control of high vacuum tubes of any description. The means provided consist of a shunt circuit of adjustable resistance, so adapted to the tube that variations in the degree of vacuum in the main tube will produce corresponding variations in the currents in the shunt circuit. These currents react in such a way as to control the vacuum in the main tube. The Sayen tube will be found fully described and illustrated in the *Journal* for June, 1898, and reference is made to this article for further details. The Scott award is recommended to the inventor. [*Sub-Committee.*—Arthur W. Goodspeed, Chairman; D. Anson Partridge, C. W. Reed.]

*Self-Lubricating Journal Box.*—Jos. S. Cook, Atlanta, Ga.

This improvement consists in surrounding the bearing part of the box with a cavity in which the grease is placed, the journal-bearing being connected with this cavity by holes in the top and bottom, and also by a slot formed by removing some of the metal at the inner part of the joint of the two parts of the box. The cup has a plug which closes the cavity, but which is removed when filling. The lubricant is introduced in any convenient manner.

In use the cavity is filled with grease, which completely surrounds the

metal of the bearing part of the box, the journal producing sufficient heat to melt the grease, and permitting it to flow through the holes and the slot.

The slightly-increased cost of this box in weight of metal and in covering the casting producing the cavity is offset by the removal of grease-cups and candle-oilers often used with ordinary boxes, and the making of a journal-box compact and covered, preventing dust and other foreign matter from getting into the journal, and having a cavity below the journal, allowing grit and other particles to settle.

The report concludes that this journal-box is an improvement over others of its class, being more compact and closed, yet well adapted to the use of Albany grease or similar lubricating substances which depend upon a rise in temperature to lubricate.

The Certificate of Merit is granted to the inventor. [*Sub-Committee.*—J. Logan Fitts, Chairman; H. F. Colvin, C. A. Hexamer, Hugo Bilgram.]

*Steam-Trap.*—Antoine Heintz, Liège, Belgium.

ABSTRACT.—The Heintz steam-trap consists of a metallic box in the shape of a semicircle, with a lid held on by bolts, the joint rendered tight by a gasket, and containing the following parts:

At one side of this box is a flange for attaching a discharge from a steam system, and at the other side provision is made for an attachment for carrying off the discharge from the trap. A spring is provided at one end of the tube, for keeping it tight against a screw which regulates the amount of, and temperature at, the opening of the valve.

The operation is as follows: Supposing the trap to be cold and the valve open, water may pass through, but when steam comes to the trap the tube becomes heated. This tube, being elliptical in section and filled with a volatile hydrocarbon, elongates as the heat vaporizes the hydrocarbon, thus producing pressure. After the tube loses its heat, the valve opens again, allowing more liquid to pass, but closes as soon as there is enough heat given to the tube to expand it. Experiments made by the investigating committee demonstrated that the trap operated well under high and low pressures.

The sub-committee's investigation disclosed the fact that the Heintz trap is an improved form of trap devised originally by Mr. Alfred Peyer, and constructed by Schmerber Brothers, of Mulhouse, Alsace. The scheme of the bent tube with its contained liquid is exactly similar to the Heintz tube, and its operation is also practically identical.

The report finds that the Heintz trap is a successful improvement of the application of the bent tube originally made for this purpose by Mr. Peyer. The applicant is awarded a Certificate of Merit. [*Sub-Committee.*—Arthur M. Green, Jr., Chairman; J. M. Emanuel, Frank P. Brown, Robt. D. Kinney, Henry F. Colvin.]

*Roller-Bearing.*—John W. Hyatt, Newark, N. J.

ABSTRACT.—This roller-bearing resembles a closely-wound spiral spring, made from a strip of steel of a rectangular section, forming an elastic spirally-wound tubular roller. The mode of supporting the rollers and the frames confining them are substantially identical with the methods long in use with solid rollers.

The investigating committee made comparative experiments to ascertain the relative resistance of the Hyatt roller-bearing and a solid steel roller to endwise thrust when confined between plates to which pressure was applied. The resistance to rolling was accurately measured by its reaction on the platform of a scale. In one set of experiments the faces of the plates were planed, in another series these faces were left rough as they came from the rolls. The pressures were increased gradually during the tests until a maximum of 25,200 pounds was reached, corresponding to from 700 to 878 pounds per lineal inch of roller.

To make sure that the rigidity arising from the application of screw-pressure might not have given a more favorable result in the case of the flexible roller, a controlling experiment was made, in which the pressure was applied by a weight acting on a lever, in which the pressure would be due to gravity alone.

The results of both sets of experiments were substantially uniform and were distinctly favorable to the Hyatt bearing.

The report is favorable, and recommends the Scott award. [*Sub-Committee.*—James Christie, Chairman ; Spencer Fullerton.]

*Compound Locomotive Engine.*—Clifton Reeves, Trenton, N. J.

On reconsideration of this subject, in consideration of a protest from the inventor, the committee confirmed the conclusions of its previous report. See this *Journal*, 145, 239.

*Counterbalancing Locomotive Driving Wheels.*—Philip Z. Davis, Lometa, Texas.

Action similar to the foregoing was taken in this case (see *Journal*, 144, 470.)

*Venturi Meter.*—Clemens Herschell, Boston, Mass.

This is an application of the well-known principle of the Venturi tube to the measurement of the flow of water in quantities so large as to be incapable of measurement by any of the meters in common use. There was also submitted, in connection with the Venturi meter, a registering device invented by Messrs. Fredk. N. Connet and Walter W. Jackson, of Providence, R. I.

The inventions supplemented each other, and were reported on conjointly. The committee directed the report to be referred for publication *in extenso*.

The Elliott-Cresson Medal is proposed in acknowledgment of the invention of Mr. Herschell, and the Scott award is recommended to Messrs. Connet and Jackson. [*Sub-Committee.*—John C. Trautwine, Jr., Chairman ; John E. Codman, Rudolph Hering.]

*Smoke Nuisance Ordinance.*—The sub-committee charged with the preparation of a draft of an ordinance to be transmitted, with the approval of the Institute, to the Bureau of Health of the city of Philadelphia, presented such a draft, which was very freely discussed, and in consequence of several criticisms upon certain of its features, it was referred back to the sub-committee for amendment.

Mr. A. M. Greene, Jr., a newly-elected member of the Committee, was presented to the chair, and took his seat as a member. W.